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Energy Research Abstracts

Abstracts 6495–9029

Office of Scientific and Technical Information
UNITED STATES DEPARTMENT OF ENERGY

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Energy Research Abstracts

Purpose

Energy Research Abstracts (ERA) provides abstracting and indexing coverage of all scientific and technical reports, journal articles, conference papers and proceedings, books, patents, theses, and monographs originated by the U.S. Department of Energy, its laboratories, energy centers and contractors. *ERA* also covers other energy information prepared *in report form* by federal and state government organizations, foreign governments, and domestic and foreign universities and research organizations. Foreign information is obtained through the International Energy Agency's 14-nation Energy Technology Data Exchange, the International Atomic Energy Agency's International Nuclear Information System, or nation-to-nation agreements. **Please note that *ERA* coverage of nonreport literature is limited to that generated by Department of Energy activity.**

Scope

ERA is comprehensive in its subject scope, encompassing DOE's research, development, demonstration, and technological programs resulting from its broad charter for energy sources, supplies, safety, environmental impacts, and regulation.

The citations presented in *ERA* are available for on-line searching as records within the Energy Data Base. The current-year records are available on the Integrated Technical Information System (ITIS). The entire data base is available through commercial on-line vendors.

Availability

DOE and DOE contractors who have OSTI deposit accounts can obtain *ERA* (regular issues and annual indexes) from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831, Attention: Information Services. For further information, call (615)576-8401, FTS 626-8401. *ERA* is also available at authorized GPO Depository Libraries. (List is provided on the inside back cover.)

ERA is available to the public on a subscription basis from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The subscription rate for 24 semimonthly issues is $184.00 for domestic subscribers and $230.00 for foreign subscribers. A single issue costs $27.00, domestic, or $33.75, foreign. Cumulative indexes are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Managing Editor, Audrey B. Smith
Technical Editor, M. Catherine Grissom

Information Sources

The citations presented in *Energy Research Abstracts* are a subset of the worldwide energy information provided to the Office of Scientific and Technical Information (OSTI) through exchange agreements with foreign sources and through exchanges or contracts with U.S. organizations.

The **Energy Technology Data Exchange (ETDE)** was established by the International Energy Agency to promote cooperation among members in conducting appropriate energy-related research and development programs through the development of a formal central information sharing system. In accomplishing the objectives of the ETDE, members select, abstract, and index relevant research information published in their countries in accordance with Exchange standards. OSTI serves as the central receiving and processing center for this information, which it then disseminates to national centers in the participating countries. The following countries are currently members of the ETDE:

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The **International Nuclear Information System (INIS)** was established to promote the exchange of information on nuclear science and technology. Its operation is similar to that of the ETDE, with the INIS Secretariat being located in Vienna, Austria. Currently, 75 countries and 14 international organizations are members of INIS. OSTI serves as the INIS national center for the United States.

In the exercise of its rights and responsibilities under the agreements to which it is a party, the **Office of Scientific and Technical Information** both receives information from the above sources and submits U.S.-produced information to them. In addition to materials generated by the Department of Energy, this U.S.-produced information is gathered from other government agencies as well as under contract with private information processing companies. All input is computer processed and entered into a data base for on-line retrieval. The data base serves as well for the production of numerous OSTI publications.

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The coverage of literature in this publication includes several document types, ranging from technical reports to journal articles to books. The principal data elements included in these citations are:

1. **Abstract number** within volume.
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3. **Title and subtitle** (non-English title may appear in parentheses, if applicable).
4. **Author(s).** First 10 names in the data record are printed, then "et al." is listed.
5. **Author affiliation.** Only first one is listed, in parentheses after author(s) to which it applies.
6. **Collaboration,** if present.
7. **Corporate author(s)** identifying corporation responsible for document.
8. **Patent assignee and number** for citations of patent documents or applications.
9. **Journal title, volume, and issue** for citations of journal articles.
10. **Date of publication.** If not known, a processing date is in brackets.
11. **Number of pages** or page range.
12. **Language** of document if non-English.
13. **Monograph title** if citation is an analytic (part, chapter, or paper) of a larger monograph.
14. **Publisher's name and location** for documents published by a corporate or commercial source.
15. **Sponsoring organization.**
16. **Contract or grant number.**
17. **Secondary identifying number;** may be a conference number.
18. **Conference title, location, and date,** if applicable.
19. **Order number.** The "DE" order number may be used for ordering from NTIS or OSTI, as appropriate. The "TI" prefix is valid only at OSTI.
20. **Sources of availability** from which a copy of the document may be obtained; usually appear as abbreviations. (See information on following page.)
21. **Drop note** or explanatory statement.
22. **Abstract.**
23. **Subject descriptors.** Listed only if no abstract or only a brief statement is included.

Sample Citations

Report

1849 (DOE/ER/40438–T1) **[Development of a hydrogen and deuterium polarized gas target for application in storage rings]: Progress report.** Haeberli, W. Phys. VI collaboration. Wisconsin Univ., Madison (USA). Dept. of Physics. [1989]. 12p. Sponsored by DOE Energy Research. DOE Contract FG02-88ER40438. Order Number DE89007246. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This paper briefly discusses the Wisconsin test facility for storage cells; results of target tests; the new UHV...

Report Analytic

18500 (INIS-SU—69, pp. 30-32) **Transition energies in Ne-like ions. Correlation effects.** Vainshtejn, L.A. AN SSSR, Moscow. Fizicheskij Inst. 1988. (In Russian). In *Experimental and theoretical physics. Collection.* Order Number DE89780060. Available from NTIS (US Sales Only), PC A03/MF A01; INIS.

Kratkie Soobshcheniya po Fizike.; no. 6.

SILVER IONS/energy-level transitions; XENON IONS/energy-level transitions; CORRELATIONS; D STATES; E STATES;...

Journal Article

19055 **A theoretical and experimental investigation of long-pulse, electron-beam-produced rare gas plasmas.** Brake, M.L.; Repetti, T.E. (Energy Beam Interaction Lab. of the Dept. of Nuclear Engineering, Univ. of Michigan, Ann Arbor, MI (US)). *IEEE (Institute of Electrical and Electronics Engineers) Transactions on Plasma Science (USA)*, 16(5): 581-589 (Oct 1988). (CONF-881020–: Symposium on radiation physics, Sao Paulo, Brazil, October 3, 1988).

Visible emission spectroscopy (380-650 nm) has been performed on intense, electron beam (1 kA, 300 ns, 300 kV) produced Ar, Kr,...

Patent

18045 **Polarization of fast particle beams by collisional pumping.** Stearns, J.W. To Dept. of Energy, Washington, DC. USA Patent 4,724,117. 9 Feb 1988. Filed date 19 Oct 1984. vp. Available from Patent and Trademark Office, Box 9, Washington, DC 20232.

A method for polarizing a fast beam of particles by collisional pumping, comprising the steps of generating a beam...

How To Order from the Availability Sources

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Report literature, usually identified by an alphanumeric identifier at the beginning of a citation, is available from the sources listed in the citation (see example of element 20 on page iii). Often the sources are listed as abbreviations. Corresponding addresses are provided at right from which documents with these abbreviations may be ordered. When "OSTI" is given, **DOE and DOE contractors may order these documents from OSTI.** (However, check with your library or information organization which may require that orders go through them to OSTI.) The public should order from NTIS or from one of the other agencies listed in the citation. To expedite processing, an order form is provided in the back of this publication. NOTE: The order numbers provide quicker access for report ordering. Use the order number where possible.

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NTIS U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

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Office of Scientific and Technical Information
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Non-report literature generally is available from the commercial publisher or corporation listed in the citation. These documents may also be available for loan from local libraries. First, check with the local library. Other sources of information are:

Journal articles *Chemical Abstracts Service Source Index (CASSI)* tells which libraries, both U.S. and foreign, contain a journal and the available years. *Ulrich's International Periodicals Directory* contains information on the journal and its publisher. For librarians, another source of information is On-Line Computer Library Center (OCLC), for interlibrary loans.

Books, conferences, and monographs The source for these publications is the publisher or the originating society, organization, or institution. DOE-supported conferences and individual papers reporting DOE-supported research may be available as reports from OSTI.

Foreign material The Linda Hall Library is an excellent source of foreign materials. For translations of foreign language material, contact the Library of Congress National Translation Center. For material difficult to locate, check with the British Library Document Supply Centre.

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National Translation Center
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202-707-0100

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LS23 7BQ
United Kingdom

How To Use the Indexes

Five indexes are provided for approaching the content of each issue of *Energy Research Abstracts*. Descriptions of entries in these indexes follow.

Corporate Author Index
The corporation, organization, or institution responsible for the issuance of the document is listed in this index. The entries are arranged alphabetically and provide the title and citation number of the reference. For example, the listing for the "Report" sample citation would appear as shown at right.

Wisconsin Univ., Madison (USA). Dept. of Physics
[Development of a hydrogen and deuterium polarized gas target for application in storage rings]: Progress report, 15:18494 (R;US)
Wisconsin Univ., Madison (USA). Lab. of Genetics
Organization of the R chromosome region in maize: Final progress report, June 1, 1983–May 31, 1986, 15:18255 (R;US)

Personal Author Index
Each author's name listed on a document cited in this issue is indexed. An index entry provides title and citation number; for secondary and other names, a cross-reference is given to the primary author name where the full index entry is located.

Hadley, D.L., *See* Lee, A.D., 15:17651
Haeberli, W., [Development of a hydrogen and deuterium polarized gas target for application in storage rings]: Progress report, 15:18494 (R;US)

Subject Index
This index lists the main subject descriptors assigned to each record by indexing professionals. A secondary or qualifier term is used where necessary to describe materials, objects, and processes. Document titles may be enhanced with additional informative phrases where necessary. An excerpt from this index appears at right.

HYDROGEN ISOTOPES
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HYDROGEN 4
TRITIUM
Neutron-Rich Isotopes
Study on the strong neutron-rich nuclei of lightest elements, 15:18686 (RA;SU;In Russian)

Contract Number Index
DOE technical reports are listed by contract number. Each entry also provides the primary corporation or organization cited for that contract number. A typical entry is shown.

FG02-88ER40438 **Wisconsin Univ., Madison (USA). Dept. of Physics**
15:18494 DOE/ER/40438–T1
FG02-88ER60664 **Rogers and Associates Engineering Corp., Salt Lake City, UT (USA)**
15:17641 DOE/ER/60664–1

Report Number Index
Technical report literature is indexed by the alphanumerical identifier of the report. Patent documents and conferences are included for convenience. Each entry lists the citation number, the source of availability of the document, an indicator of presence at a GPO depository library, order number, and distribution category. A typical entry is:

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T1 15:18494 NTIS, PC A03/MF A01 - OSTI E 1.99: DE89007246 MF-411

Subject Contents

The subject content of *Energy Research Abstracts* is arranged as shown below. The two-digit and four-digit category numbers printed here illustrate the category number assignment used in the data base records.* The following list includes all of the 39 first-level and the 308 second-level categories. Because each issue of *ERA* publishes citations only for those documents announced during the past semimonthly period, some subject categories may not be present in every issue.

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*The numerical subject category scheme is used in the storage, retrieval, and manipulation of bibliographic information entered into DOE's data systems. Categories and definitions for the complete set of six-digit numbers are given in DOE/TIC-4584, *Energy Data Base: Subject Categories and Scope*.

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Energy Research Abstracts

01 COAL, LIGNITE, AND PEAT

6495 (ARC–CE-02437) **Alberta Research Council [research reports].** Alberta Research Council, Edmonton, AB (Canada). [1982]. 104p. (CE–02437). Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

This research report contains papers about coal liquefaction, and, in particular, with coal liquefaction catalysts, with the flow and heat transfer properties of coal slurries, with calculations of the in-situ gasifaction of coal, the manufacturing of metallurgical coke, the infrared spectra of petroleum resins and asphaltenes, and the future of coal in Alberta. Separate abstracts have been prepared for 8 papers.

6496 (ARC–CE-02437, pp. 7) **Coal utilization trends in Alberta.** Plessis, M.P. du (Alberta Research Council, Edmonton, AB (Canada)). Alberta Research Council, Edmonton, AB (Canada). [1982]. (CE–02437). In *Alberta Research Council [research reports].* Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

The characteristics and recoverable reserves of Alberta's coal resources are described. Current production levels and projected increases to meet Alberta's requirements for thermal coal and new industrial appriciations are presented. Alberta Energy Resources Conservation Board forecasts that the Province's total annual requirements for sub-bituminous coal by the end of the century will be about 60 M tonnes. The major consumption (45 M tonnes) will be for electric power generation. Industrial applications such as stem raising for in situ oilsands projects, fuel for the cement industry and feedstock for ammonia plants are forecast to require about 15 M tonnes. Some 12 to 14 operating mines will be required by the end of the century to meet these projected production levels. Other potential requirements for subbituminious coal are direct export of thermal coal, and feedstock for future plants producing synthetic fuels and chemicals to supply new markets within and outside Alberta. Technology is available for coal gasification and the synthesis of hydrocarbons, ammonia, methanol and the production of hydrogen, and commercial plants can be built if and when there is sufficient economic incentive. Other coal conversion technologies likely to approach commercial maturity in the next decade are pyrolysis and hydoliquefaction. Both these process routes are receiving increasing attention from Government Agencies and industry. Research and Development initiatives and opportunities in these areas are described. 8 refs., 5 figs., 6 tabs.

0103 Preparation

Refer also to citation(s) 6597, 6648, 6731, 6733, 6796, 8186, 8189

6497 (CMRC–8902, pp. 199-210) **New coal preparation systems for various types of utilization.** Onodera, Jiro (The Coal Mining Research Centre, Japan, Tokyo, Japan). Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

In this report, bulk coal cleaning automation, variable wave form type pneumatic jig, pretreating on coal to be liquefied by dense media cyclone, fluidized bed type dry coal separator, and desulfurization of coal by microorganism, are presented. In coal preparation plants, quality of coal are controlled by various process such as screening, bulk coal cleaning etc, however with the expansion of recent coal utilization, requirement for quality becomes severe and diversified, therefore necessity to improve quality of coal is demanded. About the latest trend of development in coal cleaning system, automation experiment for Drewboy bulk coal cleaning machine is conducted for more than 35 mm in particle size. As pneumatic jig is the principal screening method in coal preparation plants, coals are sent to water tank in the plant and pulsation of water is excited by compressed air sent into the tank, however variable wave form type pneumatic jig is developing at present. As a part of the technology development for coal liquefaction, impurities in coal and removal of liquefaction inactive components are researched. Besides the above, fluidized bed type dry coal separating method or desulfurization of coal by microorganism are researched. 6 refs., 13 figs.

6498 (VTT-SYMP–98) **Comparison of drying methods of wet coal and peat.** Kanervirta, M-L.; Hallikas, J. (eds.). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. 189p. (In Finnish, Russian). (CONF-8701165–: Seminar on comparison of drying methods of wet coal and peat, Jyvaeskylae (Finland), 6 Jan 1987). Order Number DE90728211. Available from NTIS (US Sales Only), PC A09/MF A01.

An delegate of energy research experts from the USSR visited in Finland 5.-9. January 1987. This visit was a part of the Finnish-Soviet cooperational program in the field of energy research, and dealt comparison drying methods of mist fuels and creation of a proposal for cooperational development of rational drying methods. The delegate met the representatives of The Technical Research Centre of Finland (VTT), and the representatives from Ahlstroem Oy, Imatran Voima Oy and Tampella Oy, and visited Rauhalahti peat fueled power plant and Ahlstroem Oy in Varkaus, there the delegate was informed of experiences on flue-gas drying, of the utilization of steam operated fluidized-bed dryer and operation of peat and coal fueled power plant. A seminar, the presentations of which are collected in this publication, was held in Jyvaeskylae 6th of January. The discussions between the Finnish and Soviet experts dealth questions concerning drying of fuel in energy production. The aim of the discussions was to start the cooperational research between Finland and Soviet Union. The main target of inspections were e.g. steam operated fluidized-bed dryers, which are economical and the harmful emissions into the environment of which are low. The steam operated kiln dryers and use of them in drying of fuels of poor flow properties were discussed, as well as the mathematical modelling of the dryers.

6499 **Beneficiation of a bituminous coals and a lignite coal by agglomeration using novel binding oils.** Timpe, R.C. (Univ. of North Dakota Energy and Mineral Research Center, Grand Forks (USA)); Knudson, C.L.; Mack, P. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 352-358 (1988). (CONF-8806136–: American Chemical Society Division of Fuel Chemistry meeting, Toronto (Canada), 5-10 Jun 1988).

Illinois No. 6 and both as received and hot water dried Zap (IndianHead) North Dakota lignite were agglomerated with Mandan refinery decant oil containing either p-xylene or deodorized rectisol naphtha from the Great Plains Gasification Plant. The effectiveness of each of the binding oils on agglomeration was determined from ash reduction and organic recovery as a function of mixing speed, mixing time, particle size, and oil-to-coal ratio. Results indicated that, although the ash reduction was significant in the Mandan decant/rectisol naphtha binder for both coals, greater reduction was achieved with the Mandan decant/p-xylene. Higher mixing speeds, longer mixing times, smaller particle size, and binder to coal ratio of 0.35 gave the greatest ash reductions. Agglomeration time was shortened substantially when either p-xylene or rectisol naphtha was added to the Mandan decant in place of using Mandan decant alone as binder.

0104 Processing

Refer also to citation(s) 6716, 6720, 6731, 6739, 6745, 6772, 6788, 6793, 6796, 6817, 7053, 7103, 7479, 7485, 7712, 8002, 8004, 8005, 8103

6500 (ARC–CE-02437, pp. 9) **Search and selection of catalysts for coal liquefaction.** Pakash, S. (Alberta Research Council, Edmonton, AB (Canada)). Alberta Research Council, Edmonton, AB (Canada). [1982]. (CE–02437). In *Alberta Research Council [research reports].* Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

Existing catalyst technology poses many problems when applied to direct coal liquefaction. This report is an overview of the scientific principles for the search and selection of suitable catalysts for coal liquefaction. The basic functions for a coal liquefaction catalyst are: rehydrogenation of the hydrogen transfer component (slurry oil), hydrogenolysis of large molecular fragments removed from the original coal structure, and heteroatom removal. In coal conversion and in the upgrading of coal liquids, there are a number of poisons and agents which may affect the chemical integrity of the catalyst. Desulfurization, denitrogenation and deoxygenation are discussed. The considerations of immediate concern in the selection or preparation of a suitable catalyst are: the hydrogenation function must be selective, i.e., the catalyst must resist poisoning by sulfur and nitrogen; the acidity must be optimum to aid in bond cleavage, but not so great as to lead to oven-cracking or to catalyst poisoning by ammonia; the catalyst should resist attrition and sintering; the catalyst must allow reacting molecules to reach active sites, but screen molecules capable of blocking these sites; the catalyst should have a reasonably large internal surface and a density compatible with the process in which it is to be used. The factors which are important in determining the final state of the catalyst are texture, support, and mode of preparation. 21 refs., 4 tabs.

6501 (ARC–CE-02437, pp. 22) **Petrographic composition and liquefaction behaviour of North Dakota and Texas lignites.** Pakash, S. (Alberta Research Council, Edmonton, AB (Canada)); Carson, D.; Ignasiak, B. Alberta Research Council, Edmonton, AB (Canada). [1982]. (CE–02437). In *Alberta Research Council [research reports].* Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

Two US lignites (from Texas and North Dakota) were density fractionated, using appropriately prepared mixtures of liquid halogenated and nonhalogenated hydrocarbons. Petrographic analyses confirmed that the procedure resulted in enriched density fractions of specific macerals. Liquid yields obtained upon solubilization with tetralin at 430C and 5.5 MPa hydrogen pressure decreased with increase in the density fraction in case of both the lignites. On plotting the total solubilities of lignites and their density fractions versus their huminite contents, a reasonably good linear correlation (particularly for North Dakota lignite) was obtained. A tentative conclusion was drawn that in North Dakota lignite (contrary to Texas lignite) macerals other than huminite did not significantly contribute to liquid products generation. 14 refs., 5 figs., 7tabs.

6502 (ARC–CE-02437, pp. 5) **Finite element heat transfer modeling of underground coal gasification.** Gibb, W.J. (Alberta Research Council, Edmonton, AB (Canada)); Ozum, B. Alberta Research Council, Edmonton, AB (Canada). [1982]. (CE–02437). In *Alberta Research Council [research reports].* Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

Underground Coal Gasification (UCG) is a method by which currently unrecoverable coal can be burnt within the seam to produce low to medium calorific valve gases. UCG involves simultaneous processes of chemical kinetics and heat and mass transfer which interact to govern the consumption characteristics. This paper describes the finite element solution of the two- and three-dimensional transient heat conduction equation with variable thermal conductivity and heat sink terms. It is to be hoped that the heat transfer model can be coupled to other process models (mass transfer, chemical kinetics, and standard mechanics) to provide a state versus time solution so that resource recovery can be maximized. 9 refs., 5 figs.

6503 (ARC–CE-02437, pp. 5) **Coal liquefaction heat transfer: Measurement and modeling.** Ozum, B. (Alberta Research Council, Emdonton, AB (Canada)); Plessis du, M.P. Alberta Research Council, Edmonton, AB (Canada). [1982]. (CE–02437). In *Alberta Research Council [research reports].* Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

Liquefaction plants have significant investment in heat exchanger process equipment, heat transfer phenomena of coal slurries with a gas phase (mainly H_2 or CO) present must be well understood. This paper briefly describes an experimental heat transfer apparatus for coal slurries under typical liquefaction conditions which is being constructed at the Alberta Research Council. Coal-oil slurry hydrogen or carbon monoxide two-phase heat transfer in a tube flow is modeled. In the model, slurry viscosity is assumed to be Newtonian, and constant throughout the tube. Non-Newtonian behavior and temperature dependence of viscosity might be taken into account to improve the model. For bubble flow, interfacial area and heat transfer coefficient, or better the product of these two terms must be known. For smaller Reynolds numbers, second order terms must also be taken into account. Experimental work is required to test the model. 2 refs., 1 figs., 1 tab.

6504 (ARC–CE-02437, pp. 5) **A novel method for metallurgical coke production.** Ignasiak, B. (Alberta Research Council, Edmonton, AB (Canada)); Carson, D. Alberta Research Council, Edmonton, AB (Canada). [1982]. (CONF-8108182–: 28. congress international union of pure applied chemistry, Vancouver (Canada), 16 Aug 1981; CE–02437). In *Alberta Research Council [research reports].* Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

A major effort has been devoted to the development of methods for the production of high stability coke from feedstocks that do not contain an expensive coking component. In particular, it has been found that preheating the coke-oven charge in an inert atmosphere and at temperatures between 150 and 350 C is useful. The principal benefit of such a treatment is a substantially shortened carbonization time and, hence, a greater oven productivity. In some cases, such a treatment also resulted in an improved mechanical stability of the coke. This has been attributed to a higher bulk density in the oven and a better thermal conductivity of the charge after the removal of moisture. On the other side, it has been widely accepted that even very slight oxidation dramatically affects the rheological properties of particularly caking coals and the preheated charges are, as a rule, characterized by reduced maximum dilation. It appears therefore, that the changes in coke strength may accrue from inadvertent oxidation of the coal during preheating, and the results of the studies presented in the paper substantiate this view. 5 refs., 6 figs., 4 tabs.

6505 (CMRC–8901, pp. 52-58) **Coal data base for liquefaction.** Okada, Kiyoshi (The Coal Mining Research Centre, Japan, Tokyo, Japan); Kanbayashi, Yutaka. Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Current data in the file, and statistical analysis and retrieval functions are presented of the coal database under development as the basis of coal selection for liquefaction. The database includes the analytical data and properties on 140 specimens of 47 kinds of coals such as 18 kinds of Canada, 7 of Australia, 17 of the USA, 5 of Japan and others widely ranging from brown coal to high volatile bituminous coal. The database is composed of a sample information file and analytical/experimental file. Such information as sample, sampling, geographical, geological, seam, mining and transpotational information and being prepared for the former, while such analysis data as proximate, ultimate, ash, ash fusion, petrographic and hydrogenation analysis data are being prepared for the latter. The statistical analysis functions include correlation analysis, multivariate analysis and other methods. As an example, a screening method to select liquefaction feedstocks based on oil yields is presented. 1 fig., 4 tabs.

6506 (CMRC–8901, pp. 93-107) **Effects of the rank, the maceral composition and the char morphology on the combustibility of the pulverized coal.** Matsuoka, Shuichi (Idemitsu Kosan Co., Ltd., Tokyo, Japan); Yamada, Shuji. Coal Mining

Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

The relations between a maceral composition or combustibility and a char morphology produced under the equivalent conditions to actual combustion were examined. Laser heater, small drop tube furnace, turbulent flow furnace and laminar flow furnace were used as test equipment, and 14 coal ranks ranging from sub-bituminous coal to medium volatile bituminous coal were used as specimens. To examine precisely the differences of volatile matter release rates or char combustion characteristics obtained from different coal ranks, based on the precise observation of the char morphology, char particles were classified into the following six types: network structure, thin walled balloon, thick walled balloon, micro disrupted, skeleton and unfused block type. As a result, the skeleton or unfused block type char from inertinite, and the thick walled balloon type char with an optical anisotropic texture from vitrinite had less combustibility. Maceral reflectance distributions were also useful as a new index for a char combustibility. 7 refs., 27 figs., 3 tabs.

6507 (CMRC–8901, pp. 127-138) **Development of formed coke process.** Okuhara, Toshimitsu (The Committee for Research and Development on Formed Coke of the Japan Iron and Steel Federation, Tokyo, Japan). Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Demonstration test results during 1984-86 of the 200t/d continuous formed coke pilot plant were summarized. The plant was operated 9 times during total 579 days, and its total coke throughput reached to 93,000t. As for the carbonization facility, a operation stability was established by a continuous 200t/d operation during two months or more, the relation between reasonable carbonizing conditions of coke and blended coal characteristics was clarified, and the addition rate of a binder was decreased to 6.5%. The recovery of furnace gas sensible heat was expected to reach to 30 - 40% accompanying the enhancement of heat balance in a carbonizing process, and in blast furnace tests, the formed coke could be used sufficiently as a substitute for conventional chamber oven coke. The feasibility study based on a commercial scale 3,000t/d facility indicated that although the economics of the process depended on coal characteristics, it was more useful than a chamber oven process under reasonable conditions. 15 refs., 22 figs., 2 tabs.

6508 (CMRC–8901, pp. 233-269) **Hot gas cleanup technology for integrated gasification combined cycle power generation.** Isshiki, Akira (The Coal Mining Research Centre, Japan, Tokyo, Japan); Sugitani, Tsuneo; Kobayashi, Shigeru; Fukui, Jun. Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Results of the hot gas cleanup technology development project were reported on a hot gas desulfurization facility and hot gas dedusting facility, which has being promoted for integrated gasification combined cycle power generation since 1974 as a part of the Sunshine Project. The desulfurization facility using iron oxide as sorbent was composed of a two-stages fluidized bed absorber and sorbent regenerator, SO_2 reducer and sulfur condenser. It achieved 95% or more in desulfurization at 420 - 480^{0}C absorber temperature, 85% or more in sorbent recovery at 600 - 780^{0}C regenerator temperature, and 99% or more in recovered sulfur purity. The dedusting facility using quartz sand as filter medium was composed of two moving charge filter bed type dust collectors and a dust separator, and it achieved 5mg/Nm^3 or less in dust content at a collector outlet under normal operative conditions. Various data for the stress corrosion cracking of pressured or hot gas exposed parts was obtained accompanying the solutions for a long term durability. 4 refs., 23 figs., 17 tabs.

6509 (CMRC–8902, pp. 245-271) **IGCC R and D project in Japan.** Hozumi, Shigetomo (The Coal Mining Research Centre, Japan, Tokyo, Japan); Shih, J.W. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

The low calorific coal gasification power generation R and D was explained in project summary. The Sunshine project taking the opportunity of oil crisis, being started in Japan in 1974, with taking up coal within one of the national projects, the low calorific coal gasification power generation R and D project was started. This project comprises a combined cycle power generation, to use gasified/refined gas as fuel to feed the gas turbine for the power generation and, then, produce steam by exhaust gas from the gas turbine for the power generation, again, and can be in expectation to largely heighten the power generation efficiency. The two-stage airblow pressurized fluidized bed system in the gasification plant, process mainly comprising the fluidized bed absorption tower in the desulfurization plant and moved bed filter system in the dust removal system were planned to be developed. A gasification process develpment unit was constructed in 1975. Next, through constructing and operating a pilot plant headed by a pilot gasification unit, the design of demonstration plant was made and all completed in 1987. 17 figs., 15 tabs.

6510 (CMRC–8902, pp. 272-281) **Flexibility of coal species in fluidized bed coal gasifier (Part 2).** Shih, J.W. (The Coal Mining Research Centre, Japan, Tokyo, Japan); Fujioka, Yuichi. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

In order to elucidate the fluidized bed coal gasification furnace in coal-by-coal basis adoptability, it was studied, by using a pilot plant in the Coal Mining Research Center, Japan and basic bench-scale tester in Mitsubishi Heavy Industries. The coal gasification power generation system is taken notice of as a system, high in efficiency and low in environmental pollution. As coal, imported to Japan, has a variety of kinds, the coal gasification furnace, adoptable to various kinds of coal, is needed. The coal gadification reaction velocity and clinker characteristics by a bench scale tester were tested with use of a laboratory scale pressurized coal gasification tester and hot model tester, respectively. Since 1985, a coal-by-coal basis adoptability test has been made by a 40ton/d pilot plant. Through those tests, the fluidized bed coal gasification furnace became predictable in optimized operation method and almost all the kinds of coal were known to be able to be used. Moreover, coal, regarded to be inappropriate, was given a possibility to be gasified with a modification in furnace and change in conditions. 2 refs., 8 figs., 5 tabs.

6511 (CONF-891001–11) **Process and recycle oils in two-stage coal liquefaction.** Burke, F.P.; Winschel, R.A.; Robbins, G.A. Consolidation Coal Co., Library, PA (USA). Research and Development Dept. [1989]. 4p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC22-84PC70018. From International conference on coal science; Tokyo (Japan); 23-27 Oct 1989. Order Number DE90004143. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Over the last decade, work by Lummus-Crest Inc. (Lummus), Hydrocarbon Research Inc. (HRI), and by the participants in the Wilsonville Advanced Coal Liquefaction facility (Wilsonville) has led to Two-Stage Liquefaction process concepts which achieve high yields, good product qualities, and minimize hydrogen consumption. Demonstrated process improvements have reduced anticipated product costs, and point the way to further cost reductions. Part of this development has been a systematic evaluation of process and recycle oil characteristics, conducted by Consol under DOE funding. Frequent (often daily) samples of key process streams are analyzed to relate recycle and product oil composition to process operating conditions and results. This paper provides a comparison of single- and two-stage recycle and process oil characteristics. 10 refs., 1 tab.

6512 (CRIEPI-W–88002) **A study on simultaneous hot gas cleanup technology for coal derived gas.** Akiyoshi, H. (and others). Central Research Inst. of Electric Power Industry, Tokyo (Japan). 1989. vp. (In Japanese).

This report describes simultaneous hot gas cleanup technology tor coal derived gas, specifically, the performance and problems for utilization of the presented simultaneous hot gas cleanup system. The main points are: a system with electrostatic granular bed filter combined with moving bed type desulfurization method is considered to be most suitable, because it is high in both collection efficiency and desulfurization performance; since the pollution velocity by the char particulate adhesion is the same as the moving velocity of the reaction zone by desulfurization, the cost of this system is very low; the problems to be solved are the drop of desulfurization performance caused by the adhesion of char and the powdering and sintering of the desulfurization sorbent in the regeneration system.

6513 (CRIEPI-W–88007) **Long term reliability of desulfurization sorbent for hot coal gas.** Kobayashi, M. (and others). Central Research Inst. of Electric Power Industry, Tokyo (Japan). 1989. vp. (In Japanese).

This report aims to determine the conditions in which carbon deposits on iron oxide desulfurization sorbent and to evaluate the influence of the carbon on the cracking of the sorbent. Iron oxide powder and the sorbent in coal gas were reduced at high temperature and high pressure. The products were identified by X-ray analysis. The carbon contents of the products were determined by a CH corder. The following results were obtained: (1) carbon deposition reactions occur under the condition in which the sorbent is used; (2) the carbon was deposited in several forms: Fe_3C, Fe_5C_2 and amorphous carbon; (3) hydrogen sulfide (H_2S) retarded the carbon deposition process; (4) the sorbent has an effect in reducing the amount of carbon deposition; (5) a slight amount of carbon was deposited on the sorbent in the first reduction with coal gas. No crack appeared on the sorbent in this process.

6514 (CRIEPI-W–88011) **Measurement of size distribution of coal char in coal derived gas.** Ito, S. Central Research Inst. of Electric Power Industry, Tokyo (Japan). 1989. vp. (In Japanese).

This report relates to the measurement of particle size distributions of coal char in coal derived gas and the dependence of alkali concentration on the particle diameter. In order to measure size distributions of coal char in high-temperature, high-pressure and high dust concentration gas streams, a sampling apparatus using Andersen stack sampler was developed. This apparatus has the following characteristics: (i) can obtain size classified samples in high-temperature and high-pressure streams such as coal derived gas; (ii) can be applied to a high dust concentration gas, because the sampling probe has gas dilution function. Using this apparatus the following have been obtained: (1) the coal char generated in a pressurized two-stage entrained bed gasifier may contain fine particles much more than predicted from past measurements. Scanning electron micrographs show that fine particles of nearly 0.1μ in diameter are contained in a large quantity; (2) the concentration of alkali metals contained in the coal char is low in fine particles, which shows that the evaporated amount of alkali metals in the coal gasification process is small.

6515 (CRIEPI-W–88012) **The long term reliability of desulfurization sorbent for hot coal gas desulfurization.** Shirai, Y. (and others). Central Research Inst. of Electric Power Industry, Tokyo (Japan). 1989. vp. (In Japanese).

High temperature desulfurization is necessary to achieve an IGCC power generation system of high thermal efficiency. Iron oxide desulfurization process of fixed bed is being researched and developed at Yokosuka Research Laboratory. Iron oxide sorbent of this process is used repeatedly by regeneration. It is important that the performance of this sorbent is stable during desulfurization/regeneration cycles. In order to investigate the stability of this sorbent, we need to evaluate the factors that lead to the drop of desulfurization performance. One of these factors is the change of sorbent physical properties. The physical properties of this sorbent manifested during desulfurization/regeneration cycles were investigated. The following results were obtained: 1. this sorbent is made of glass fibers, TiO_2 particle layer and Fe_2O_3 SiO_2 particle layer. Hydrogen sulfide (H_2S) absorbing capacity is influenced by the physical properties of Fe_2O_3 SiO_2 particle layer; 2. the specific surface area and pore volume of Fe_2O_3 SiO_2 particle layer decrease according to the increase of desulfurization/regeneration cycles and these physical properties become stable after 10 cycles; 3. the decrease of specific surface area leads to the decrease of H_2S capacity. In this test, H_2S capacity is made constant after 10 cycles because the specific surface area is constant.

6516 (CRIEPI-W–88013) **Study on removal of ammonia in coal derived gaseous fuel (Part 2).** Yamauchi, K. (and others). Central Research Inst. of Electric Power Industry, Tokyo (Japan). 1989. vp. (In Japanese).

In this report, the method for removing ammonia from coal derived gaseous fuel was studed by injecting small amounts of O_2 and NOx into it. It was clarified that under the condition of injecting O_2 by 1000 ppm into the fuel at a reaction temperature of over 700 degrees C, the ammonia concentration can be lowered by adding about 500 ppm of NO into the fuel, compared with the case of adding no NO.

6517 (CRIE-W–87030) **Study on low calorific gas combustion (4).** Nakata, Toshihiko; Sato, Mikio; Yamauchi, Koji. Central Research Inst. of Electric Power Industry, Tokyo (Japan). Jul 1988. 28p. (In Japanese). Order Number DE89910307. Available from NTIS (US Sales Only), PC A03/MF A01.

This report describes the fundamental characteristics of partial premixed combustion being thought effective to improve the combusting stability of low calorific gaseous fuel derived from coal and evaluated the application to gas turbine combustor. The limiting calorific value resulting flow off at the partial premixed combustion appeared at higher excess air ratio and about 550 kcal/m^3N fuel can be combusted at the partial premixed rate of 20% and excess air ratio of 5. This tendency was remarkable for higher CO/H_2 ratio in fuel gas. The CO concentration was constant and about 50ppm or less at 20% premixed rate, independent of the excess air rate. The fuel NO_x increased a little by the partial premixed combustion, but became very few by the combination with 2 stage combustion. The partial premixed combustion can improve the flame stabilizing performance in the primary combustion area, so that much lower NO_x is thought possible by combining this with the 2 stage combustion. 6 refs., 20 figs., 4 tabs.

6518 (CRIE-W–87035) **Development of low BTU gas turbine combuster for coal gasification combined cycle power generation system. 1 Evaluation of prototype combustor.** Sato, Mikio; Abe, Toshio; Nakada, Toshihiko; Fukazawa, Mamoru; Hisamatsu, Toru; Hasegawa, Hiroshi; Hisasa, Shoichi; Yoshine, Toshiyuki; Yamada, Masahiko. Central Research Inst. of Electric Power Industry, Tokyo (Japan). Sep 1988. 54p. (In Japanese). Order Number DE89910305. Available from NTIS (US Sales Only), PC A04/MF A01.

This report evaluated characteristics of 1,300C class prototype gas turbine combustor (CGT 1001 type) for coal gasification and pressure characteristics with 1/2 scale of the combustor model. CGT 1001 type combustor which was designed for fuel of 1,000kcal/m^3N calorific value as the full scale prototype combustor used for 150,000kW gas turbine with air jet entrained bed coal gasification showed the combustion efficiency of 99.5% or more, even if the calorific value decreased to 630kcal/m^3N. When NH_3 concentration in fuel was 1,000ppm at the rated condition of CO/H_2=3, 95% or more NO_x emission was caused by NH_3 contained in the fuel, where the conversion rate from NH_3 to NO_x was 73% and emitted NO_x concentration was 300ppm. It was clarified that the pressure increase in the combustor decreased the conversion rate from NH_3 to NO_x. 7 refs., 37 figs., 5 tabs.

6519 (CRIE-W–87036) **Development of gas turbine combustor for coal gasification. Part 2 Low NOx combustion technology on prototype combustor.** Ninomiya, Toru; Sato, Mikio; Abe, Toshio; Yamauchi, Koji; Hisa, shoichi; Hasegawa, Hiroshi; Yoshine, Toshiyuki; Yamada, Masahiko. Central Research Inst. of Electric Power Industry, Tokyo (Japan). Oct 1988. 38p. (In Japanese). Order Number DE89910301. Available from NTIS (US Sales Only), PC A03/MF A01.

The design for air distribution on the prototype combustor was changed and emission characteristics of CO and NO_x, and liner metal temperature change were tested and evaluated to reduce NO_x emitted from the 1,300C class gas turbine combustor for entrained bed coal gasification combined cycle system. The conversion rate from NH_3 to NO_x in mixing and intensified CGT 1002 type

combustor at the rated condition (excess air rate of 2.0) where the calorific value of fuel was 1,000kcal/m^{3}N and the outlet gas temperature of combustor was 1,300C, was about 68% at the condition of 1,000ppm NH_3; and was about 51% in the prototype rich-lean combustor (CGT-1003), showing that the rich-lean combustion is effective to suppress the fuel NO_x. The CO emitted concentration from CGT-1003 was about 50ppm or less at 2.0 to 12 excess air rate, indicating that the rich-lean air distribution design was effective to reduce the emitted CO concentration at higher excess air rate. 1 ref., 23 figs., 4 tabs.

6520 (CRIE-W–87043) **Study-for operating time of porous ceramic filter in hot gas clean-up process.** Ito, Shigeo; Makino, Nakao; Watanabe, Masatoshi; Tanaka, Takashi; Shinozaki, Shin'ichi; Kawamura, Toshi. Central Research Inst. of Electric Power Industry, Tokyo (Japan). Jun 1988. 38p. (In Japanese). Order Number DE89910299. Available from NTIS (US Sales Only), PC A03/MF A01.

Permeability of porous filter used for the combined power generation with coal gasified fuel must be stabilized for long term under high temperature and pressure. In this report, a method to evaluate the change of friction loss in filter medium and a change of cleaning intervals were studied. As to the change of friction loss it is reasonable to notice the additional pressure which is the difference between the base pressure loss after cleaning and the pressure loss in a new filter. To eliminate the apparent influence of test condition, it is suitable to use the coefficient which is the additional pressure loss divided by gas viscosity and filtration rate. The coefficient of additional pressure loss increases linearly with the cleaning cycles on log-log coordinates. As the result it is possible to estimate the change of permeability. The operating time is estimated to be 5,000 hours, if the lower limit of cleaning interval is set at 20 minutes. 8 refs., 25 figs., 4 tabs.

6521 (CRIE-W–88001) **Proposed method for the prediction of wall temperature of gas turbine combustor for coal gasification. No. 1 Development of basic program.** Yamauchi, Koji; Abe, Toshio; Sato, Mikio; Yamada, Masahiko. Central Research Inst. of Electric Power Industry, Tokyo (Japan). Jun 1988. 33p. (In Japanese). Order Number DE89910297. Available from NTIS (US Sales Only), PC A03/MF A01.

Combined power generation with coal gasification requires the development of 1,300C class gas turbine combustor, but the air amount to cool the combustor liner is restricted owing to low calorific value of coal gasified fuel and further the liner wall must be cooled with air amount as low as possible to lower NO^x and to stabilize the combustion. Therefore, the high accurate prediction of liner wall temperature was studied. This prediction assumed that the thermal conduction effect was neglected, air and fuel were mixed instantaneously and the combusted gas temperature was the theoretical adiabatic flame one. This analytical program can apply to wide range of operating conditions and different cooling structures for the combustor. The calculated maximum liner wall temperature agreed well with the measurements both at the ambient and high pressure conditions, showing this program can be used sufficiently for the basic design of the combustor. It can moreover be reflected to design the air distribution to suitably cool the future liner wall. The theoretical and observed linerwall temperatures were not affected by the pressure in the low calorific gas combustion. 22 figs., 23 figs., 1 tab.

6522 (DOE/MC/21349–2738) **Reduction of erosion in elbows due to flow modifications: Final report, Phase 2.** Johnson, E.K.; Means, K.H. West Virginia Univ., Morgantown, WV (USA). Dept. of Mechanical and Aerospace Engineering. Jun 1989. 57p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC21-84MC21349. Order Number DE89011702. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The objective of this project was the reduction of erosion in elbows (bends), in pneumatic transport systems, due to flow field modification. Air was to be injected into a bend, thus modifying the flow so that the eroding particles are kept from the surfaces. The goal of this effort was to achieve erosion rates less than those of blind-tees. A fluidized blind-tee and two different air injection bends were selected for detailed investigation. The detailed investigation demonstrated that the air injection bends significantly reduced erosion rates, but never developed an erosion rate less than that for a blind-tee. Although the air injection bends' erosion rates approached those for a blind-tee; technically the blind-tee represents a simpler system and consequently will probably remain the choice of engineers concerned with erosion of bends. 20 figs., 8 tabs.

6523 (DOE/MC/23077–2734-Vol.1) **Analysis of test data from IGT high pressure fluidized-bed gasifier PDU: Volume 1.** Newman, S.A. Foster Wheeler USA Corp., Clinton, NJ (USA). Sep 1988. 52p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC21-86MC23077. Order Number DE89011692. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

An assessment of IGT's experimental data on fluidized-bed coal gasification at pressures in the range of 100-450 psig was conducted by Foster Wheeler, in conjunction with the City University of New York (CUNY) as a subcontractor. The objective of this study was to evaluate the quality, reliability, and usefulness of IGT's data which was obtained in an eight inch diameter gasifier PDU. Foster Wheeler's effort focused on the results if IGT's Phase-2 test program in which fifteen steady state tests were conducted on Illinois No. 6 bituminous coal, Montana Rosebud subbituminous coal and North Dakota lignite. The scope of this analysis included an independent check on the reported study state conditions and overall balances, as well as correlating the data relative to gas phase equilibrium and the effects of operating parameters. The results of Foster Wheeler's assessment are summarized in Volume-1 of this report. 4 refs., 13 figs., 16 tabs.

6524 (DOE/MC/23077–2734-Vol.2) **Analysis of test data from IGT high pressure fluidized-bed gasifier PDU: Volume 2: Topical report.** Avidan, A.; Shinnar, R. Foster Wheeler USA Corp., Clinton, NJ (USA). Dec 1988. 37p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC21-86MC23077. Order Number DE89011693. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Experimental data from IGT's high pressure fluidized-bed PDU for both Phase-1 and Phase-2 were checked for consistency using the invariant technique developed by CUNY. In addition, the usefulness of the IGT data relative to the design and performance projections for a commercial gasifier was assessed. 7 refs., 7 figs., 10 tabs.

6525 (DOE/PC/80023–T19) **Automation of a hydrogen meter for use in coal liquefaction plant and for determination of the effect of aliphatic hydrocarbons on hydrogen solubility and mass transfer rate in coal liquid solvents.** Liaw, Shuh-Jeng. Pittsburgh Univ., PA (USA). 1989. 198p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC22-85PC80023. Order Number DE90004145. Available from NTIS, PC A10/MF A01 - OSTI; GPO Dep.

The hydrogen solubility and mass transfer rate in tetralin for the systems hydrogen-methane-tetralin and hydrogen-ethane-tetralin at coal liquefaction conditions were studied. The amount of hydrogen released from the coal liquids and model compounds at high temperature were also investigated. A novel design for an in-situ nickel hydrogen probe was constructed and used to determine the hydrogen partial pressure. 70 refs., 60 figs., 34 tabs.

6526 (DOE/PC/90529–11) **Micropore diffusion in coal chars under reactive conditions: Quarterly progress report, March 15, 1989–June 15, 1989.** Perkins, M.T.; Calo, J.M.; Lilly, W.D. Brown Univ., Providence, RI (USA). Div. of Engineering. [1989]. 29p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FG22-86PC90529. Order Number DE90004265. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The current project is concerned with the development and application of a technique to measure micropore diffusion under actual gasification conditions. The method is an outgrowth of and related to the transient kinetic approach to the measurement of kinetic rate parameters for char-gas reactions that has been developed in our laboratory. It can be shown that the initial transient behavior of a species introduced as a step-function into a "gradientless" reactor in which char is present, is controlled by the transport resistance offered by the char micropores. Therefore, this data can be analyzed for micropore diffusion time constants. In addition, due to the time-resolved nature of the process in the reactor, the initial diffusion step is separated (in time) from any subsequent gas-solid reaction steps. Therefore, diffusion measurements can be performed under

mild gasification conditions. This quarter diffusion time constant measurements were obtained for CO_2, CO, CH_4, and N_2 diffusing in two different chars prepared from PSOC-833, and Wyodak coals. These data were analyzed using the new technique presented in the previous quarterly technical progress report. 4 refs., 15 figs., 1 tab.

6527 (DOE/PC/90538–12) **Use of basic nitrogen to chemically clean coal: Final report.** Silver, H.F.; Baldwin, M.D.; Smelker, C.A. Wyoming Univ., Laramie, WY (USA). Dept. of Chemical Engineering. 16 Sep 1989. 300p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FG22-86PC90538. Order Number DE90003321. Available from NTIS, PC A14/MF A01 - OSTI.

Four different basic nitrogen compounds of varying pK_b were investigated as precombustion desulfurization promoters in a direct coal liquefaction process. The nitrogen compounds used were tetramethylammonium hydroxide pentahydrate. 2,2,6,6-tetramethylpiperidine, 4-dimethylaminopyridine, and 5-amino-1-naphthol. A North Dakota lignite, a Wyoming subbituminous, and a Kentucky 9/14 bituminous coal were liquefied in coal derived distillate solvents containing a basic organic nitrogen compound in varying concentrations. In some runs, m-cresol was also added to the solvent. Batch microreactor experiments were conducted at 600°F or 700°F for thirty minutes under a hydrogen or carbon monoxide reducing atmosphere. Results are discussed. 47 refs., 45 figs., 24 tabs.

6528 (EPRI-GS–6485, pp. 14.1-14.43) **Update of Department of Energy hot gas cleanup programs.** Notestein, J.E. (Morgantown Energy Technology Center, WV (USA)). Electric Power Research Inst., Palo Alto, CA (USA). Aug 1989. (CONF-8810105–: 8. annual EPRI conference on coal gasification, Palo Alto, CA (USA), 19-20 Oct 1988). In *Eight annual EPRI conference on coal gasification.* Order Number DE89016762. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

This is a follow-on paper to one presented at the 1987 EPRI Gasification Conference and provides an update on events of the last year. The philosophy of enhancing the commercial viability of coal gasification-based systems through system simplification – the minimization of the number of separate process steps/units – has continued to be validated. The achievable reductions in system capital cost are impressive and result principally from two general sources: (1) improvements and refinements in hot gas cleaning approaches and (2) combining functions in one process block, e.g., combined sulfur and particulate control. Additional commonalities between combustion and gasification technologies have also been found and have led to promising distributed function approaches, e.g., in-situ desulfurization followed by a polishing step. The paper describes and quantifies the current advancements of these technologies and also looks ahead to some very advanced approaches for the future.

6529 (FSJ–8901, pp. 2-5) **Studies of catalysts for coal liquefaction (4). Comparison of activity of various catalysts on hydrogenolysis of model compounds.** Sakurai, Atsushi (Kansai Univ., Faculty of Engineering, Osaka, Japan); Harada, Yuichi; Oda, Hirokazu; Yokokawa, Chikao. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

In order to reveal features on chemical reaction of catalysts for coal liquefaction, investigation results used ten kinds of catalysts and eleven kinds of model compound had been reported. Sixty six combinations were chosen from them, tetralin was added to the reaction systems. And behaviors influence the reaction products had been further studied. Similar investigations have been conducted using additional four kinds of model compounds. In the reaction systems without using a catalyst, though naphthalene and phenanthrene were hardly reacted, other compounds were strongly reaCTED. And the reactivity of dinaphthyl system was higher than that of diphenyl system. In the case of reaction systems using catalysts, high reactivities were shown by catalysts which possess high nuclear-hydrogenation activity; in naphthalene, anthracene and phenanthrene. MoO_3-TiO_2, MoS_3, MoS_3-Al_2O_3 and NiO-SiO_2-Al_2O_3 were such high performance catalysts. 4 refs., 2 tabs.

6530 (FSJ–8901, pp. 6-9) **Studies on the catalysts for coal liquefaction. Specific behaviours of various catalysts in the hydrogenolysis of a solvent-refined lignite.** Ikenaga, Naoki (Kansai Univ., Faculty of Engineering, Osaka, Japan); Oda, Hirokazu; Yokokawa, Chikao. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

In order to elucidate the features on chemical reaction of the catalysts for coal liquefaction, the studies have been conducted using model materials correspond to a coal molecule. Furthermore, the effect of tetralin, which is a hydrogen donating solvent, on the composition of the reaction products has been investigated. In this report, experimental results on the hydrogenolysis of a Solvent-Refined Lignite (SRL) are described. Four kinds of distinctive catalyst, which were chosen among the catalysts which had so far been used, were used in the experiment. Fractional separation of the products was conducted by asphalt composition analytical method, then the features of the components were elucidated through infrared absorption spectroscopy and high resolution NMR spectrum, and the activities and directivities of various catalysts were studied. It is thought that MoO_3-TiO_2 possesses highest activity in any conditions and hydrogenative ability to aromatic nucleus among the four catalysts. 4 refs., 1 fig., 2 tabs.

6531 (FSJ–8901, pp. 10-13) **Studies on the activities of the catalysts for coal liquefaction. Hydrogenation and hydrogenolysis of the coal model compounds.** Suzuki, Toshimitsu (Kyoto Univ., Faculty of Engineering, Kyoto, Japan); Yamada, Hiroshi; Ando, Toshihiro; Watanabe, Yoshihisa. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Coal liquefaction in which various metal carbonyl compounds which are soluble in medium, and organometallic compounds such as alkyltin were used as catalyst precursors, has been studied. And high catalytic activities of these compounds in the reaction have been revealed. In this study, the hydrogenation of condensed aromatic compound and the scission reaction of carbon-carbon bonding were chosen as the model reactions using these organometallic compounds, and the comparative studies of catalyst activities for each reaction were conducted under the condition of coal liquefaction. In all cases of the hydrogenation performance of condensed aromatic compound and hydrogenolysis of carbon-carbon bonding, the catalyst obtained from $Mo(CO)_6$-S showed higher activity than the others, and the $Fe(CO)_5$-S system was next to that. This order was the same as the catalysis of metal carbonyl compounds in coal liquefaction. 5 refs., 2 figs., 3 tabs.

6532 (FSJ–8901, pp. 14-17) **Studies of coal liquefaction (55). Hydrogenation of aromatics with iron and molybdenum catalysts.** Ogata, Eisuke (The Univ. of Tokyo, Faculty of Engineering, Tokyo, Japan); Tamura, Tomoyuki; Fukazawa, Toshiharu; Nakamura, Kazumoto; Kamiya, Yoshio. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

For the purpose to clarify suitable volume of hydrogen to be supplied to the individual process in the coal liquefaction, selectivity of iron and molybdenum catalysts together with characteristics of iron catalyst in hydrogen reaction of phenanthrene (PHN), were studied. In Ni-Mo sulfide catalyst, selection to hydrogen reaction is changed in accordance to reaction temperature, much 4H-PHN was generated at 300°C of low temperature, 2H-PHN at 400°C, both of them were generated almost equally in volume at 350°C. In the reaction by iron sulfide catalyst at 300°C, 2H-PHN is generated by more than 80% in selectivity even though at 60% invert ratio and selectivity in 4H-PHN was about 10%. In a case that reserve sulfizing temperature became higher to 400°C, catalyst activity reduced. About iron sulfide, similer tendency was also recognized. 4 figs., 3 tabs.

6533 (FSJ–8901, pp. 18-21) **Studies on coal liquefaction (56). Effect of iron catalysts on the hydrocracking of 1,1'-dinaphthylmethane.** Wei, Xian-Yong (The Univ. of Tokyo, Faculty of Engineering, Tokyo, Japan); Ogata, Eisuke; Futamura, Sigeru; Kamiya, Yoshio. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987.

(In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

In the lower rank coalification coal, aromatic annulus with 1-2 annulus is bridged by methylene chain and ether linkage, and high oxygen content together with much aliphatic carbon are features of the coal. As the rank of coalification is higher, aromatic annulus composed the coal become larger, then contents of oxygen and aliphatic carbon has a tendency toward to decrease. Hydrocracking of methylene linkage which bridges aromatic annulus in the coal, is considered to be important in coal liquefaction. In this research, hydrocracking reaction of 1,1'-dinaphythymethan with various catalysts were studied as the fundamental research for the coalification reaction. The activity of Fe compound catalysts for DNM hydrocracking is low, in the circumstances without sulfer. When sulfur is added to the reaction process, activity of the catalysts is much improved by addition of sulfur to the reaction. The activity is greatly influenced by vapour phase hydrogen. DNM hydrocracking in existence of the Fe catalysts is advanced by partial hydrogenation on naphthalene annulus. 3 refs., 1 fig., 4 tabs.

6534 (FSJ–8901, pp. 22-25) **Formation of sulfate ion and its catalytic activity in coal liquefaction (1). Mechanisms of the SO_4 formation.** Kotanigawa, Takeshi (Hokkaido Univ., Faculty of Engineering, Sapporo, Japan); Takahashi, Hideaki; Yokoyama, Shin'ichi; Yamamoto, Mitsuyoshi; Maekawa, Yosuke. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

It was reported that in the use of an iron oxide-sulfur system catalyst under coal liquefaction conditions, the sulfate ion is formed even with the coexistence of high pressure hydrogen when water coexists in the system because sulfur is oxided by water. And the study on the formation structure of the sulfate ion is now being carried out. It is, therefore, necessary to consider the activities of both the sulfate ion and the sulfuric acid material to study the activity structure of catalysts for coal liquefaction reaction. In this report, the structure of simultaneous formation of the sulfate ion and the sufuric acid material from the iron oxide-sulfur system catalyst under the coal liquefaction conditions was studied. When an iron oxide-sulfur system catalyst is used under the coal liquefaction conditions, S^6? is always formed with the coexistence of water in the system. The simultaneous formation of S^6? and S^{6-} is caused by the converse claus reaction. The behaviors of the iron sulfide in the coal liquefaction reaction are as follows. Fe^2?-S_2^{2-}→Fe-S 7 refs., 2 figs., 3 tabs.

6535 (FSJ–8901, pp. 26-29) **Formation of sulfate ion and its catalytic activity in coal liquefaction (2). Catalytic activity of the sulfate ion.** Yokoyama, Shin'ichi (Government Industrial Development lab., Hokkaido, Sapporo, Japan); Yamamoto, Mitsuyoshi; Maekawa, Yosuke; Kotanigawa, Takeshi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Catalytic activity of the sulfate ion in the coexistence of water and an ion-sulfur system catalyst was studied using model compounds under the coal liquefaction reaction conditions. Diphenylmethane(DPM) and diphenylether(DPE) were used as model compounds, and the catalytic activity of the sulfate ion upon C-C and -O- bond cleavages of the sulfate ion was investigated. According to the reaction results of DPM, the reaction rate decreased remarkably with the coexistence of water in the reaction system, and moreover the selectivity of diphenylethane formation rose greatly. It is conjectured that the sulfate ion which was formed under the coexistence of water suppressed the hydrogenolysis of DPM and accelerated the formation of benzene and benzine radical from DPM. The reaction rate of DPE was a little lower than that of DPM. As the phenyl radical in this system was very unstable, products were benzene and phenyl and their selectivity was about 50%. From the above, it was found that the sulfate ion is more active upon the C-C bond creavage than upon the -O- bond creavage. 1 fig., 4 tabs.

6536 (FSJ–8901, pp. 30-33) **Formation of sulfate ion and its catalytic activity in coal liquefaction (3). Catalytic activities of the sulfate and sulfide.** Kotanigawa, Takeshi (Government Industrial Development Lab., Hokkaido, Sapporo, Japan); Yokoyama, Shin'ichi; Yamamoto, Mitsuyoshi; Maekawa, Yosuke. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Catalytic activity of iron oxide-sulfur catalyst for Taiheiyo coal was studied, being divided into two activity of sulfate and sulfide. On the experiment, the liquefaction reaction of Taiheiyo coal was divided into solvent system using tetralin as donar and into solventless system. Behavior of high pressure DTA which used sulfate or sulfide corresponding to solvent or solventless system, or used the mixture of these two as catalyst, and characteristics of liquefaction of Taiheiyo coal, were studied. About solvent system, if sulfate exists in the system at mobile condition, sulfate catalyzes dehydrogenation of solvent at a temperature below reaction temperature of coal, further it catalyzes dehydrogenatien from coal, so it was suggested that generated coal radical polymerization occured and invert ratio decreased. About solventless system, it was connected with much activity reduction due to coexistence of mobile sulfate, however coal invert ratio showed higher activity than that by FeS_2 catalyst in such a case where it combined with FeS. 1 ref., 2 figs., 3 tabs.

6537 (FSJ–8901, pp. 34-37) **Coal liquefaction using oil soluble molybdenum catalyst (Molybdenum dithiocarbamate) (2). Coal liquefaction in the presence of tarsand bitumen.** Saito, Ikuo (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Yamamoto, Yoshitaka; Sato, Yoshiki; Imuta, Kazutoshi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

As a part of study for high efficiency coal liquefaction, liquefaction of Taiheiyo coal with bitumen solvent was studied using oil soluble organometalic compounds molybdenum complex, which contains sulfur and converts to active MoS_2 under the reaction conditions. Bitumens used in the study were Athabasca and Cold lake tarsand, and Venezuela Moulitial crude oil. Oil soluble molybdem complex used as catalyst was molybdem dithio-carbamate which is used as lublicating oil additive. As the result, it was clarified that regardless of a kind of bitumen, it gave almost same invert ratio, high invert ratio was obtained like the case where tetralin was used, it gave more active invert ratio than that used red mud, it gave higher hexan insoluble invert ratio, it showed higher activity than molybdenum catalyst such as molybdenum trioxide, and a similer level of activity with $Mo/SiO_2{}^*Al_2O_3$ was shown. 8 refs., 1 fig., 4 tabs.

6538 (FSJ–8901, pp. 38-40) **Catalytic hydrocracking of SRC derived from pyrolytic liquefaction.** Hanaoka, Koji (Osaka Univ., Faculty of Engineering, Osaka, Japan); Song, Chunshan; Nomura, Masakatsu. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

In order to efficiently change solvent-refined coal (SRC) to light property, using M_oCl_5 or NiCl-LiCl-KCl complex salt catalyst, holdback complex salt catalyst, industrial use Ni-M_o and Ni-M_o sulfide catalyst, which are effective to one step catalytic cracking of various coals, hydrogenation reaction is conducted to SRC which is obtained by short time pyrolysis liquefaction reaction on Wandwoan coal, and effect of various catalysts were studied. High oil recovery rate of 69-85% is established in catalytic cracking for SRC using various catalysts on the condition limitted below 4% for gas generation. Namely, it is understood that SRC derived from pyrolysis liquefaction reaction provides high reactivity and is comparatively easyly hydrocracked, and that total hydrogen consumption is remained in low value such as 0.6-1.3%, therefore much movable hydrogen seems to be included in SRC and to be contributed on catalytic cracking reaction. 5 refs., 2 figs., 2 tabs.

6539 (FSJ–8901, pp. 41-44) **Estimation of catalyst life for hydrodenitrogenation.** Miki, Yasuo (National Chemical Lab. for Industry, Tsukuba, Japan); Oba, Masaaki; Yamadaya, Shoko; Sugimoto, Yoshikazu; Basar, A. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

In this paper, it was shown that carbazoles reaction was used for test reaction to search the hydrogenation denitrogenation catalyst for vacuum gas oil fraction (VGO), and length of the catalyst life was able to be estimated by selectivity for reaction. Further, by utilizing its result, relation between composition of the catalysts (Nickel, Cobalt, Molybdenum, Tungsten, Tungsten/Almina) and denitrogenation activity together with length of catalyst life, were studied. When contact-hydrogenation denitrogenation (HDN) of carbozoles was applied to test reaction, it was suggested that activity of the catalysts, of which selectivity was high in cyclohexane and hex-cyclohexane, easily decreased, on the other hand, the catalyst of which selectivity was high for bicyclohexyl, life of activity is long. In either catalysts, the catalyst supporting Nickel had higher selectivity for bicyclohexyl than that supporting Co. As denitrogenation coefficient was higher in the catalyst supporting Co, it was understood that the catalyst supporting Ni was superier to that supporting Co, after due consideration for catalyst life. 4 refs., 2 figs., 3 tabs.

6540 (FSJ–8901, pp. 45-48) **Study on deactivation behavior of catalyst used for hydrotreating coal-derived liquids. Comparison with HDS catalyst.** Nishijima, Akio (National Chemical Lab. for Industry, Tsukuba, Japan); Sato, Toshio; Fujimura, Yuji; Matsubayashi, Nobuyuki; Shimada, Hiromichi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

In order to develop the long life advanced hydrotreating catalyst for coal liquefaction oil, behavior of activity drop of the catalyst which was used for a long time for hydrotreating reaction of liquefaction oil from raw materials of different property, was studied. Further, it was compared with behavior of acitvity drop of the catalyst which was used for a long time for petroleum indirect and direct desulfurization process. As the result, the problems necessary to develop the long life hydrotreating catalyst for coal liquefaction oil, were clarified. About activity drop in of the hydrotreating catalyst for coal liquefaction oil, as the result is added to the past knowledge obtained by the petroleum desulfurization catalyst, activity of the catalyst falls due to adheision of nitrogen included compound and metal inclusion component on the catalyst, and change in sulfurization condition and others seems to be a cause of drop in its activity, so corrective action for the aboves were necessary. While, on hydrotreating reaction process of liquefaction oil and petroleum heavy oil, change in partial structure of active metal was newly clarified and seems to be a future problem. 5 tabs.

6541 (FSJ–8901, pp. 49-52) **Study of the catalyst for hydrotreating coal-derived liquid by EXAFS method (1). Regeneration behavior of catalysts.** Matsubayashi, Nobuyuki (National Chemical Lab. for industry, Tsukuba, Japan); Sato, Toshio; Shimada, Hiromichi; Yoshimura, Yuji; Nishijima, Akio; Mito, Yutaka. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

In order to heighten hydrotreating activity of coal liquified oil, the catalyst supporting relatively high density active metal, which was used in reactor outlet, and aggrigation of Mo was recognized already by EXAFS method (wide area X-ray absorption fine structure) which established partial structure around absorption element, was regeneratively treated, and change in sulfade and decentralization conditions of active metal Mo, was analized by applying EXFAS method, and correlation with activity was studied. While, stereo symmetric property around absorption element was compared with Mo condition by XANES (X-ray near absorption edge structure). As the catalyst subject to this study was used in relatively not so severe condition and fall in activity was considered mainly to be caused by deposition of carbonecious material, the catalyst was almost restored to original condition by baking. By the reaction for about 1400-hour, it was understood that despersion condition was easily restored to original one. 3 refs., 3 figs., 1 tab.

6542 (FSJ–8901, pp. 53-56) **Evaluation of NBCL secondary hydrogenation catalyst by 5000 hours test (1). Change in catalystic activities in PDU.** Nagae, Shin'ichi (Kobe Steel, Ltd., Tokyo, Japan); Mito, Yutaka; Saito, Kaizaburo; Nakako, Yukio. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Nippon Brown Coal Liquefaction Co., Ltd. (NBCL) is developing the two stage hydrogenation liquefaction technique subject to Australian coal. In order to utilize the Ca-Ni-Mo/Al_2O_3 catalyst on fixed bed in secondary hydrogenation process, various tests about catalystic performance were conducted so far. In this study, life confirmation test for 5000-hour was conducted to the catalyst by using 0.1 ton/day PDU. In this report, changes on elapsed time in catalystic activity and product property in hydrogenation and hydrocracking, were mainly presented. As deashed oil invert ratio decreased rapidly to some extent in early stage, from that time reduction rate became lower and it was about 10% after 5000-hour operation, further longer operation was supposed to be possible. By the change in product property, it was understood that both activity in hydrogenation and hydrocracking reaction were equally decreased, and selectivity of the above two was not changed. 3 refs., 10 figs., 1 tab.

6543 (FSJ–8901, pp. 57-60) **Evaluation of NBCL secondary hydrogenation catalyst by 5000 hours test (2). Analysis and character ization of the used catalyst.** Masuyama, Tetsuo (Mitsubishi Chemical Industries Ltd., Tokyo, Japan); Yamauchi, Yasuyuki; Kageyama, Yoichi; Kawai, Satoshi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Nippon Brown Coal Liquefaction Co., Ltd. (NBCL) evaluated the Ca-Ni-Mo/Al_2O_3 catalyst to be used to the secondary hydrogenation reaction process in two stage hydrogenation process for Australian brown coal by 5000 hours operation using 0.1 ton/day process development unit (PDU). As the result, no leakage was found in active component of Ni and Ca. Tetrahydrofuran insoluble (THFI) on the catalyst bed was almost uniform in quantity, and increase of THFI quantity with the passage of time on entire surface of the catalyst bed was not recognized. About accummulated ash by components, it was recognized that Mg was the largest in quantity, and Na was the next. As quantity of Fe included in raw material was the largest, a little of them was accummurated. Accummulation rate of Mg and Na was not changed to the elapsed time, however accummulated quantity was linearly increased with the passage of time. It is considered that the result is deeply involved in the degradation of denitrification activity with the passage of time. Degradation of catalytic property was great at the beginning of operation, however it was little changed after that. 5 refs., 6 figs., 1 tab.

6544 (FSJ–8901, pp. 61-63) **Evaluation of NBCL secondary hydrogenation catalysts by 5000 hours test (3). Performance test of the used catalyst in bench reactor.** Masuyama, Tetsuo (Mitsubishi Chemical Industries Ltd., Tokyo, Japan); Yamaura, Takahisa; Kageyama, Yoichi; Kawai, Satoshi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Japan Brown Coal Liquefaction Co.,Ltd. is developing a two-stage hydroliquefaction technology at 0.1ton/PDU on Australian brown coal. A comparison test of the catalyst performances after 5000 hour PDU operation with those of a new catalyst by a bench reactor was executed. The catalyst was Ca-Ni-Mo/Al_2O_3. Toluene solubilized coal liquefaction furnace bottom oil was used as the raw material. The invert ratios of deashed oil (DAO) by used catalyst at the temperatures of 370, 400, 430^{0}C were lower than those of new catalyst by 8-12%, but the temperature dependencies of the two were almost the same. Selectivities of the used catalyst and the new catalyst were also the same concerning such products as solvent cut, naphtha cut, water and gas, and also concerning hydrogen consumption, so when the temperature is raised (30^{0}C), even used catalyst attains the same product yield. There is no circulation to the primary hydro-reaction process and there is no characteristic change of the secondary hydro-reaction products, and the primary hydro-reaction activity is not influenced. 4 refs., 3 figs., 1 tab.

6545 (FSJ–8901, pp. 64-66) **Studies on the hydrocracking of deashed oil (5).** Kimura, Takao (Asia Oil Co., Ltd., Tokyo, Japan); Masuyama, Tetsuo; Kageyama, Yoichi; Kawai, Satoshi. Fuel

Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Preliminary sulfiding method of catalyst and the influences DAO (Delimed Ash Oil) exercises on decomposition response activity in the technical development of two-stage hydroliquefaction of Australian brown coal were studied by the TPS (Temperature Programmed Sulfiding) analysis and the X-ray Photoelectron Spectrum (XPS) analysis. The catalyst was Ca-Ni-Mo/Al_2O_3. As the gramma value becomes greater, the DAO invert ratio is increased and the coak formation is reduced. The additive Ca fixed to Mo atom by high-dispersion due to the $CaMoO_4$ structure exists as CaS near the MOS_2 polymer structure by sulfiding. The catalyst which went through structural rearrangement by sulfiding in this way forms a hydrocracking active spot by MoS_2 (Mo-Ni-S structure). Ca interacts with a part of the solid acid spot which is formed accompanied with the formation of a hydrocracking active spot. As a result, the adsorption of the organic nitrogen compound and the polynuclear aromatic compound which are the preceding body of coak is weakened, and the lowering of the initial catalyst activity is suppressed. 4 refs., 4 figs.

6546 (FSJ–8901, pp. 67-70) **Study on the interaction of the mineral matter in Morewell char with oxygen-containing gases by using a TPD technique.** Zhang, Zhan-Guo (Tohoku Univ., Sendai, Japan); Kyotani, Takashi; Tomita, Akira. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

To find out the catalyst response of mineral matters in Morwell char, oxygen containing gas was adsorbed to steam gasified char, and the TPD (Temperature Programmed Desorption) pattern of the oxygen containing gas which desorbs from this sample was studied. The oxygen containing gas adsorption was executed in three series: H_2O adsorption, O_2 adsorption, and two-stage adsorption of H_2O and O_2. Then, TPD experiment was carried out. The desorption peak of H_2O is derived from the decomposition of $Ca(OH)_2$ formed by the reaction of CaO and H_2O in the char. The 840K desorption peak of CO_2 is derived from the decomposition of $CaCO_3$ formed in the char. This decomposition occurred at the far lower temperature than that of the decomposition of pure materials, and this is based on the mutual response of the mineral matters and carbon by the catalyst response of Ca. Wide range of CO_2 desorption from low temperature to 1,000K is derived from the decomposition of oxide on the carbon surface. By stage adsorption of H_2O and O_2, CaO formed by the decomposition of $Ca(OH)_2$ and CO_2 from the carbon surface responded and became $CaCO_3$, whose decomposition brought about a sharp CO_2 desorption peak at 780K. 5 refs., 3 figs.

6547 (FSJ–8901, pp. 71-73) **Effect of addition of metallic salts on the carbon structure during carbonizing brown coal.** Otsuka, Yasuo (Tohoku Univ., Sendai, Japan). Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Effect of addition of metallic salts on the carbon structure during carbonizing brown coal was studied. Australian Yallourn brown coal was used, and the addition rate of metallic salt was 10% in metallic component. In the heat treatment of raw coal, the average interlayer spacing (d002) by x-ray diffraction did not decrease despite the raise of the temperature, and it was 3.45A in 2300K heat treatment. The apparent crystallite height L_C was small and showed graphitization resistance. When Ca salt was added, d002 decreased to 3.40A at 1900K, and it was about the same as the spacing of the random-layer-structure carbon. Unlike Al and Ca, Mn, Fe, Co and Ni salts showed remarkable effects in the heat treatment of even 1,400K, and d002 decreased to 3.40 - 3.42A. With the addition of Mn and Fe, d002 decreased further more at 1900K, and it was near the spacing of graphite-structure carbon. L_C was 210A. With the addition of $Fe(NO_3)_3$, the carbon becomes graphite structure, and with $FeCl_3$, random-layer structure. The chemical type and the distribution condition of Fe at the initial stage of carbonization have great influences. 7 refs., 2 figs., 1 tab.

6548 (FSJ–8901, pp. 74-77) **Gasification of carbon impregnated with Na-Ca-Fe composite catalysts in various gaseous environments.** Haga, Tetsuya (Tohoku Univ., Sendai, Japan); Nishiyama, Yoshiyuki. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Catalyst behaviors in the composite use of Na, Ca and Fe catalysts in the carbon gasification were studied. The sample was granulated active carbon on the market, and it was gasified at 800^0C running various kinds of gases under normal pressure. Gasification in steam-He by two-component system composite catalyst showed more invert ratio than the additive property rule of each catalyst component. The invert ratio was the maximum in the use of an equimolar composite catalyst, but it did not exceed quite a lot the invert ratio of Ca's single use. It was shown that there was a geometrical activity increase in the reaction rate of the equimolar composite two component catalyst system. Gasification reaction in H_2-CO_2 was slow, and CO and H_2O were formed in the shift reaction. Na, Ca, Fe and two component catalysts except for Fe-Ca were inactive in the formation of CH_4 in H_2. The reaction rate and the invert ratio of the equimolar composite two-component catalyst system in various kinds of gasification agents were twice the values of the additive property rule. The three-component system of Na-Ca-Fe showed the maximum activity in every gasification agent. 3 refs., 9 figs., 2 tabs.

6549 (FSJ–8901, pp. 78-81) **Catalytic activity of rare earth compounds for the coal gasification.** Suzuki, Toshimitsu (Kyoto Univ., Faculty of Engineering, Kyoto, Japan); Nakajima, Seiji; Watanabe, Yoshihisa. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

CO_2 and steam gasification reaction by adding various kinds of rare earth compounds to coal was carried out. La $(NO)_3$ and $Ce(NO_3)_3$ showed higher initial activity than Na system in the gasification of Yallourn coal, but at the invert ratio of more than 30%, the activity decreased. Even the initial activity of Sufco coal and New Lithgow coal, which have much ash contents and are of low reactivity, was high, and it was decreased with the progress of gasification. Compared with alkaline metal, rare earth compounds show higher activity in the range of low addition amount and low invert ratio. Even with the deliming of coal, the gasification speed is decreased. The lowering of the catalyst activity is not, therefore, simply due to the reaction of rare earth compounds and the ash content. The CO_2/CO ratio of the gas formed by the Ce system steam gasification is high, and its water gas transfer reaction progresses more than by Na system. At the temperature of 500-650^0C, only the reaction structure of mCO_2 + nM -> mCO + MnOm is shown, and at the temperature of more than 800^0C, MnOm + mC -> mCO + nM is shown and gadification is accelerated (M and Mn are rare earth metals). 3 refs., 5 figs., 2 tabs.

6550 (FSJ–8901, pp. 82-85) **Basic studies on coal gasification. Relationship between petrographic constituents of coals and overall reactivity of their carbons in gasification.** Hashimoto, Manabu (Kansai Univ., Faculty of Engineering, Osaka, Japan); Oda, Hirokazu; Yokokawa, Chikao. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Coals of five brands separated by the specific gravity and their compositions were analyzed, and at the same time the reactivity of carbon upon CO_2 was measured. Even in a coal of single brand, the composition is not uniform, and two fractions separated by the specific gravity (the float component and the sediment component separated at the boundary of 1.35 specific gravity) are mutually heterogeneous. The yields of the float component and the sediment component are different according to the species of the coal. The sediment component has much ash content, and inert component, and the coal rank of its vitrinit is high. There were no differences in the volatile components of the float and sediment components except for two brands. The specific surface area of carbon is increased as the coal rank is lower and as there is more ash content. The crystal face space of carbon is decreased when the coal rank is higher, but in a same brand, the crystal face space is greater in

the sediment component. This is because there is much inert component in the high specific gravity fraction. The gasification reactivity of each fraction upon CO_2 can be shown by the heat balance weight decrease ratio up to the gasification ratio of 30%. Up to 30% gasification ratio, the reactivity of a brand coal can be represented by the averaging reactivity before the separation treatment. 1 ref., 3 figs., 2 tabs.

6551 (FSJ–8901, pp. 86-88) **Catalytic gasification of carbonaceous materials by mechanical mixing method.** Takahashi, Atsushi (Kitami Inst. of Tech., Hokkaido, Japan); Yamada, Tetsuo; Suzuki, Tsutomu; Honma, Tsuneyuki. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

The change of carbonaceous materials pulverized mechanically, and the gasification activity of CO_2 by mixing and adding mechanically an acetic acid Ni catalyst were studied. Resin coal as amorphous carbon, and graphite (GP) as crystal carbon were pulverized and used. The catalyst gasification was compared between the mechanical mixture by a grinder and impregnation method. With five-minute mechanical mixture, gasification of GP was admitted at the low temperature of 500^{0}C. The low temperature activity became greater with more pulverization, and with 300-minute mixture, the invert ratio attained 85% at less than 750^{0}C, which was almost the same as the activity of impregnation method. The resin coal had the same tendency. By mechanical pulverization of carbonaceous materials, cleavages are caused and an active site is formed. In the air this active site adsorbs oxygen and forms surface oxide. As a result of measuring this surface oxide by temperature-up desorption method, the desorption temperature range and the desorbed amount of CO had strong correlation with the temperature range and the invert ratio of gasification reaction. In the resin coal, the desorbed amount of CO was much, NiO catalyst was deoxided at a low temperature of 600^{0}C, and active free Ni showed gasification reaction. 3 refs., 2 figs.

6552 (FSJ–8901, pp. 89-92) **Relationship between material balance and energy efficiency in coal gasification reaction.** Kaiho, Mamoru (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Makino, Mitsunori; Kobayashi, Mituso; Yamada, Osamu; Yamashita, Yasumasa; Fujinami, Shosaku. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Relation between material balance and energy efficiency (ϵ) in coal gasification reaction was analyzed. Whether the gasification agent is CO_2 or H_2O, the total amount of CO and H_2 formed is twice the theoretical combustion amount of O_2. Energy efficiency of gasification by $O_2 + H_2O$ is decided only by the ratio(x) of the supplied amount of O_2 against the theoretical combustion amount of O_2. 1 -ϵ is heat loss, and 1 - ϵ and x are in a linear relation (12 formulas). The x at ϵ=1 is ideal. Formation of unconverted carbon is a parallel displacement of the (12 formulas), and the energy efficiency is decreased as much as unconverted carbon is gasified into CO. Formation of CH_4 is a parallel displacement toward as much increase of heat loss as the reaction heat amount, and the energy efficiency becomes smaller than the oxygen ratio obtained from the (12 formulas) is proportion to the formed amount of CH_4. Relationship of the oxygen supply amount, the steam decomposition amount and the formed gas composition that make the energy efficiency the maximum was studied in comparison with the results of balance calculations. 2 refs., 6 figs.

6553 (FSJ–8901, pp. 93-96) **Investigation of tar and gas formation in coke oven.** Uno, Takeo (Nippon Steel Corp., Tokyo, Japan); Nishi, Tetsu; Okuhara, Toshiaki. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Thermal decomposition and secondary reaction, secondary reaction in particular, of the coke formation process were experimented. Each product is formed rapidly in the first ten seconds, and thereafter the formation rate becomes constant regardless of the coal type. Formed gases are H_2, CH_4, C_2H_4, C_2H_6, CO_2, and CO. Up to 800^{0}C much CH_4 is formed and at 900^{0}C H_2 is increased. The reactor is saturated at the gas formation ratio of 40% and the tar decomposition ratio at this time is 45%. Primary tar has much long chain aliphatic carbon, and the changing process by the temperature almost coincides with the size tendency of the C-C dissociation energy. There are two increase types of aromatic carbon: a condensed ring development type and a decomposition type. The aromatic characteristic became constant at 900^{0}C at 0.94. Secondary reaction is influenced by the amount of generated material in the plastic zone, the distribution factor to the coke side, and the situation in the furnace on the coke side. As a result of analysis, more than 90% of the gas generated in the plastic zone goes toward the coke layer side. Flow of gas to the coal layer side is increased with the increases of the coal grain size and porosity. 1 ref., 7 figs.

6554 (FSJ–8901, pp. 97-100) **Effect of demineralization and metal addition on the flash pyrolysis of coals.** Miura, Koichi (Kyoto Univ., Faculty of Engineering, Kyoto, Japan); Mae, Kazuhiro; Uchiyama, Motoshi; Hashimoto, Kenji. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Effect of demineralization and metal addition on the flash pyrolysis of coals was studied. Five species of coal were demineralized and deashed, and then metal was added by soaking them in the metallic salt solution. Na, Ca and Mg are easy to remove, but K and Fe are hard to remove from the Morwell coal. K, Ca and Fe are easy to remove and Mg is hard to remove from the Taiheiyo (Pacific) coal. Overall metal content of the Taiheiyo coal decreased from that of raw coal after soaking because of the ion exchange activity. The tar yield of high coal rank coal decreased by deashing, and that of low coal rank Morwell coal increased. When Na, K, and Ca were added to Morwell coal, the thermal decomposition yield showed the reverse yield tendency of the deashed coal. The yields of tar and gas, especially H_2O, decreased and the yield of CO_2 increased. That means that metal cation has catalytic activity. The tar yield of the Taiheiyo coal decreased and showed the same yield tendency of the deashed coal. This is because the metal content of the soaked coal was less than that of raw coal and had a similar result as deashing. 6 refs., 5 figs., 3 tabs.

6555 (FSJ–8901, pp. 21-216) **Studies on coal swelling in heated solvent (3). Influence of coal ranks and specific gravity.** Nakada, Masao (Government Industrial Research Inst., Kyushu, Saga, Japan); Sakai, Tsuyoshi; Arita, Seiji. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

In the previous report, the characteristic swelling behaviors of Wandoan coal in various solvents were described. In this study, the swelling behaviors of Wandoan, Wabamun and Illinois coal at the temperatures of 100, 200 and 300^{0}C in hydrogenated anthracene oil (HAO), were examined. Furthermore, for Wandoan coal, specific gravity fractional separation was conducted, and its effects were examined. An oder of the rank of coalification is as follows; Wabamun < Wandoan < Illinois. In Wabamun coal, insignificant swelling was found at the temperature of 300^{0}C. In Wandoan coal, degree of swelling of about 1.4 was shown at 200^{0}C, and it was further increased at 250^{0}C or above. The degree of swelling of Illinois coal was slightly smaller than that of Wandoan but similar swelling trends were shown in both coals. Two specific gravity fractions (1.24 or below, 1.32 or above) of Wandoan coal were obtained, then swellings of these fractions in HAO at 200^{0}C were taken place. It was found that lighter specific gravity fraction was more swelled than heavier one. 2 refs., 5 figs., 1 tab.

6556 (FSJ–8901, pp. 101-104) **Study on the secondary reactions of volatile matter from coal.** Xu, Wei-Chun (Tohoku Univ., Sendai, Japan); Tomita, Akira. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

The secondary reactions of volatile matter formed by the heat decomposition of coal were studied. When the temperature becomes 800^{0}C, in proportion with the residence time, decomposition products of lower molecule are formed, and the aliphatic group of more

than C_2H_6 and PCX (phenol, cresol, xylenol) are decreased. On the other hand, CH_4, C_2H_4, benzene and toluene are increased. At 900°C, with the increase of the residence time, decomposition progresses rapidly and the production of coak is increased. When the residence time is from 0.4 to 14 seconds, the temperature required for the same amount of formation becomes 100C lower. That is, secondary reaction can be controlled by temperature and time, and the optimization of product composition is possible. Sintered catalyst Al_2O_3 containing SiO_2 accelerates the secondary reaction of volatile matters. In particular, when the surface area is large, the formation of more than C_2 is decreased, and at the temperature of more than 800°C, nothing except for CH_4 and benzene is observed. At the temperature so high, the acid strength distribution has nothing to do, and not only surface area but also other properties exert influences. 1 ref., 1 fig., 1 tab.

6557 (FSJ–8901, pp. 105-107) **Flow properties of slags formed from coal ashes.** Yamashita, Yasumasa (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Kaiho, Mamoru; Makino, Mitsunori; Kobayashi, Mitsuo; Yamada, Osamu. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

The temperature dependency factor of the coal ash viscosity was studied. While the viscosities of Miike and Horona coals are increased linearly accompanied with the fall of the temperature from the low viscosity at 1600°C to caking, the viscosities of Taiheiyo coal and Blair Athol coal(B coal) rise very rapidly in the temperature amplitude of about 200°C. There are also these two patterns in the viscosities of mixed ash in which sample ashes are mixed at a constant rate. When Miike coal ash is mixed with B coal ash equivalently, the temperature at the jet floor limit viscosity 50P_a becomes 200°C lower than that of the simple B ash coal, and the temperature change also becomes linear. But when Taiheiyo coal ash or Horonai coal ash are mixed with B coal ash equivalently, there is no effect. This is because while the viscosity of the ash composed only of non-crystalline change by the temperature linearly, with the mixture of B coal ash, Taiheiyo coal ash and Horonai coal ash, which deposits crystalline, the viscosity rises rapidly when the temperature is lowered. The silica ratio of ash is in a linear relation with viscosity when the temperature is constant. So it can be a barometer for viscosity prediction, ash mixing, and the reforming of melting characteristic. 3 refs., 4 figs., 1 tab.

6558 (FSJ–8901, pp. 108-111) **Investigation on fusibility of CaO-ash mixtures.** Miyauchi, Tsunekazu (Tokyo Univ. of Agriculture and Tech., Faculty of Tech., Tokyo, Japan); Ninomiya, Yoshihiko; Hirato, Mitsuho. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

The melting rate of the coal ash content was studied by adding CaO flux. Plateau coal (P coal), Blair Athol coal and Datong coal were used. At the flux addition rate of 15-25%, the melting of the ash content progresses with the rise of the temperature and the vitrification is accelerated. At the addition rate of 0-10%, there is much non-crystalloid and the ash content is not melted. At the addition rate of 35-50%, the ash content is not melted either. The melting of the ash content is more influenced by the temperature than by the reaction time. For the P coal ash, the Ca addition rate of 15-20% was effective at 1200°C and with 90 second reaction time. The ash content added with 20% CaO is composed of α-Quartz, Anorthite, Cyclowollastonite, and Gehlenite, and it's about the same as the composition of the eutectic point which is the lowest of the SiO_2-Al_2O_3-CaO three-element system; the ash content is melted from around here. In a short melting of the ash content, the influence of the temperature is big. When there is much Al_2O_3 content, the ash content is hard to melt, and the melting accelerating effect of the flux is hindered. 2 refs., 6 figs., 1 tab.

6559 (FSJ–8901, pp. 112-115) **Basic study on fusibility of coal ash with additives. Effect of Al_2O_3 in coal ash.** Ninomiya, Yoshihiko (Tokyo Univ. of Agriculture and Tech., Faculty of Tech., Tokyo, Japan); Asami, Masahiko; Hirato, Mitsuho. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

To find out the rate-determining factor of the solution of the coal ash added with flux, the influence of Al_2O_3 in the ash content was studied. When there is much Fe or little Al_2O_3 in the raw coal ash, the fusing point is the minimum at around 20% CaO flux addition; and with more addition, the fusing point rises. With the addition of 30-45%, the fusing point becomes constant between 1200 and 1300°C and the influence of the ash content becomes nil. Eith the addition of 30% CaO flux, the fusing point rises in proportion to the content of Al_2O_3 in the ash but it is not influenced by the type of the ash content. With the addition of 0-60% Fe_2O_3 flux, the fusing point fell rapidly in proportion to the increase of additive amount with the ash content of less than 20% Al_2O_3, and gathered between 1050 and 1100°C. In the case of high Al_2O_3 ash content, however, the fusing point did not fall below 1200°C unless a lot of Fe_2O_3 was added, and the addition was ineffective. 4 refs., 8 figs., 1 tab.

6560 (FSJ–8901, pp. 119-122) **Route to reduce coke formation in upgrading heavy oils.** Kubo, Jun'ichi (Nippon Oil Co., Tokyo, Japan); Yamashita, Tadakazu; Kamiya, Kozo; Suzuki, Kenji. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

A pilot plant of 0.1 bbl/d capacity utilizing a reactor of the natural internal refluxing process was used to the experiment to apply a hydrogen donating solvent as a method to surppress coke formation when upgrading heavy oils. The most important features are to carry out the cracking under the coexistence of a hydrogen donating solvent and catalysts and are to use the two step reaction where reaction products from the cracking reactor are hydrogenated in a hydrogenator. Arabian heavy vacuum residue was used as the raw material, a demetallization catalyst sold in the market was used in the cracking reactor and desulfurization catalyst was used in the hydrogenator. Formation of toluene insolubles were suppressed by cracking under the coexisting condition of hydrogen donating solvent and catalysts. The toluene insolubles produced in the cracking reactor were converted to solubles in the hydrogenator and the toluene insolubles decreased to about 0.1 wt%/raw oil. 3 refs., 5 figs., 4 tabs.

6561 (FSJ–8901, pp. 127-130) **Thermochemical studies on the reactivity of model solvent compounds in coal liquefaction (2).** Kawai, Satoshi (Nippon Brown Coal Liquefaction Co., Ltd., Tokyo, Japan); Kageyama, Yoichi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

It is necessary to investigate the correcting requirement when applying the linear free energy relation by researching the liquidus concentration of the model solvent due to mixing and the change of free energy due to pressurization, in the coal liquefaction using the model solvent. This research used dihydrophenanthrene, dihydroanthracene and quinolin as the model solvents and 1-methylnaphthalene and tetralin as the coexiting solvents and calculated the gas phase-liquidus equilibroum composition under conditions of high temperature, high pressure, and hydrogen blowing. Further, similar calculation was carried out with solvents used practically for coal liquefaction. Following results were found: concentration ratio(for example, model solvent/tetralin) in liquidus shows the difference when there is the difference of properties between model solvents; hydrogen fugacity shows different ratio to total pressure depending on the condition but for coal liquefaction solvents, the fugacity may be approximated with the total pressure. 4 refs., 2 figs., 6 tabs.

6562 (FSJ–8901, pp. 131-134) **Studies on the solvents in coal liquefaction (5).** Masunaga, Toshio (Mitsubishi Chemical Industires Ltd., Tokyo, Japan); Moriya, Kikuo; Aiura, Masato; Kageyama, Yoichi; Kawai, Satoshi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

The effect of saturated hydrocarbons in equuilibrium solvent for coal liquefaction on the coal liquefaction was studied with primary hydrogenation and secondary hydrogenation. Morwell coal was

used as the experimental sample and n-hexadecane and tetralin were used as the primary hydrogenation equilibrium solvent and the model solvent. Cycloparaffin mixture was obtained by fractional distillation with single distillation of product gotten through hydrogenating creosote oil using Co-Mo/Al_2O_3 catalyst and by separating saturated hydrocarbons with silica gel chromatography. N-paraffin increased TI yield and QI yield in the primary hydrogenation, which is mainly caused by the decrease of donor hydrogen in solvents. Cycloparaffins are thought to have donor hydrogen equal to or less than that in equilibrium solvents. Secondary hydrogenation does not affect on DAO conversion rate for the amount of saturated hydrocarbon used for this time experiment. 3 refs., 1 fig., 4 tabs.

6563 (FSJ–8901, pp. 135-138) **Reaction mechanism of coal liquefaction using model compounds. Pass of hydrogen transfer during coal liquefaction.** Ouchi, Koji (Hokkaido Univ., Faculty of Engineering, Sapporo, Japan); Ito, Hironori; Makabe, Masataka; Sasaki, Mayumi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Path of hydrogen transfer during coal liquefaction was studied by using model compounds to clarify the reaction mechanism of coal liquefaction. This experiment used dibenzyl and benzylphenyleter as model compounds; tetralin, decalin and naphthalene as solvents; and stabilized nickel as the catalyst. When the catalyst exists under gaseous hydrogen and decalin is used as the solvent, saturated compound of dibenzyl having aromatic rings occupies 99%, one ring saturated compound, phenylcyclohexylethane occupies 1% and the conversion rate is 99.9%, indicating the perfect hydrogenation and no decomposition of dibenzyl. It was concluded that hydrogen absorption to coal was mainly caused by the direct hydrogenation of gaseous hydrogen and hardly caused by the reaction through the solvent in this study where nickel catalyst was used for hydrocracking and this conclusion could be verified in this experiment by using model compounds. 1 ref., 3 figs.

6564 (FSJ–8901, pp. 139-142) **Studies on coal liquefaction (54). Additive effect of SRC on the hydrogenolysis of the diarylmethane (2).** Koyanagi, Seiya (The Univ. of Tokyo, Faculty of Engineering, Tokyo, Japan); Futamura, Shigeru; Kamiya, Yoshio. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

This paper studied the hydrogen shuttling ability of SRC (solvent refined coal) by repeatedly using SRC in decalin and tetralin having different donating ability and by investigating the durability of their promoting effect in the hydrogenolysis of 9-benzylphenanthrene(BP). Further, the reactive mechanism of SRC was considered by evaluating the produced amounts of 1-methylindan and naphtalene caused by the solvent. When SRC of 0.4g and 0.8g was added in the decomposition reaction of 9-BP respectively, the conversion rate increased from 19% without addition to 52% and 61% respectively, indicating the remarkable promoting effect, and SRC acted as a hydrogen shuttler. Imino group in phenanthridine promotes the hydrogen transfer from tetralin to 9-BP as the hydrogen shuttler. 2 refs., 2 figs., 2 tabs.

6565 (FSJ–8901, pp. 143-146) **Interaction between coal and hydrogen donor solvent in a preheater (2). Effect of coal rank.** Sakaki, Tsuyoshi (Government Industrial Research Inst., Kyushu); Shibata, Masao; Adachi, Yoshio; Miki, Toshiharu; Arita, Seiji. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Coal-hydrogenated anthracene oil(H.AO) slurry was heat treated with a preheating condition by using a pipe type rapid heater for coal liquefaction process, and the influence of coal rank on several phenomena occurred in the preheater was studied by extracting heat treated slurry during heating process, and by investigating properties of residual particles and intermediate without particles. Six coal ranks ranging from brown coal to bituminous coal were used after grinding to 200 mesh or less as samples. Coals changed greatly by the interaction with H.AO; that is, the initial liquefaction occurred, coals were dissolved, viscosity of filtrate increased from about 300^{0}C and coal began to collaspe from about 400^{0}C to be refined. Coal of lower carbonization degree showed the lower change during the initial liquefaction. 2 refs., 5 figs., 1 tab.

6566 (FSJ–8901, pp. 147-150) **Attempts to reduce the solvent/coal ratio in the hydrogen transferring liquefaction of a Brown Coal.** Mochida, Isao (Kyushu Univ., Fukuoka, Japan); Sakata, Ryuji; Sakanishi, Kinya. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

This paper researched the effects of reactive conditions, coal activation(deashing pretreatment), and low pressure hydrogen, which enabled improvements of consumption efficiency of hydrogen from solvent and oil yield to improve the economy of coal liquefaction process and to reduce solvent/coal ratio. According to the reduction of solvent/coal weight ratio from 6/2 to 2/2 by using Australian Morwell brown coal, liquefaction yield and oil yield decreased and gas generation and preasphaltene-residue remaining rate increased, but higher hields such as 70% liquefaction yield and 60% oil yield could be ensured even at the ratio of 3/2, except higher gas yield like 25% may be the future problem. But by deashing process, gas yield decreased greatly and oil yiels increased in return. Gas and asphaltene yields decreased and oil yield increased by the corresponding amount by introducing low pressure hydrogen compared with nitrogen atmosphere. 4 refs., 3 figs., 2 tabs.

6567 (FSJ–8901, pp. 151-154) **Reactivities of some subbituminous coals in the hydrogen transferring liquefaction with hydrogenated fluoranthene under high temperature short contact time condition.** Mochida, Isao (Kyushu Univ., Faculty of Engineering, Fukuoka, Japan); Towata, Atsuya; Sakanishi, Kinya. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

This study compared and investigated liquefaction properties on three kinds of coal to be processed by the NEDOL process to get the guide giving the optimal liquefaction conditions which realize high liquid-low gas yields and low hydrogen consumption for all coals, on the NEDOL process in which research and development are being promoted as the subbituminous coal liquefaction process. The hydrogen transferring liquefaction was experimented under high temperature-short contact time condition by using hydrogen donor solvent, tetrahydrofluoranthene on two kinds of Illinois coal No.6 and Taiheiyo coal and high oil yields(60-70%) could be achieved for all three coals, although each optimal condition was different. Even if two coals exist in a same coal seam, two kinds of Illinois coal (Peabody coal and Montery coal) for which winning regions are different, indicated different liquefying reactivities. Although the donor concentration was lowered, high liquefaction yiels could be maintaned by suppressing gas generation and improving hydrogen consumption. 2 refs., 5 figs., 1 tab.

6568 (FSJ–8901, pp. 155-158) **Relationships between the properties of low rank coals and their liquefaction potentials (3). Tubing bomb coal hydrogenation.** Kanbayashi, Yutaka (Coal Mining Research Centre, Japan, Tokyo, Japan); Ishimaru, Tomohiko; Okada, Kiyoshi; Saito, Kazuki; Ikari, Masao; Hayashi, Yoshio; Osawa, Yukihiro; Iwabuchi, Yoshihiro. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

The coal field/mine evaluation tester as coal for the liquefaction must be able to quickly make the batch type liquefaction test and, as a matter of course, use a reactor which is small. In this report, by using a small tubing bomb reactor and testing, in liquefaction, 14 kinds of domestic and foreign coal sample, the thus obtained liquefaction characteristics, together with their comparison with the liquefaction test result by a large autoclave, were studied. The latter is 20% to 25% higher in oil yield than the former. However, both of them are almost equal in ratio of change in slope of regression straight line. The asphaltene yield, exactly reverse against the oil yield in relation between both of them, is about 25% higher in the former than in the latter and poorer in correlativeness than the oil yield. Those matters are judged to be due to the difference in reaction condition. And, in the former, due to the difference in reaction

temperature, the liquefaction reaction is judged to remain in the partial conversion to asphaltene. 3 refs., 7 figs., 1 tab.

6569 (FSJ–8901, pp. 159-162) **Studies on preheating stage in brown coal liquefaction (2).** Moriya, Kikuo (Mitsubishi Chemical Industries Ltd., Tokyo, Japan); Aiura, Masato; Kageyama, Yoichi; Kawai, Satoshi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

In order to prevent coke, etc. from making trouble, through grasping the pilot plant, presently operating in Australia, in liquefaction behavior inside the preheater, a basic study was made, by using a reactor provided with an infrared image furnace, able in quick heightening in temperature, for the heightening process in temperature, in particular, at the initial stage of liquefaction. As the heightening speed in temperature is high, about 150^{0}C per minute, in the preheater in the pilot plant, the radical concentration is expected to heighten, with an occurence of sudden short term pyrolysis. As a result of obtaining, by testing, the relation between the heightening velocity in temperature and unsolved THF content at each point of temperature being heightening, under the existence of octa-hydro-anthracene solvent, it was known that, in case of high heightening velocity in temperature even with a sufficient existence of migratory hydrogen quantity, pyrolytic fragment partially rebonds, as the pyrolytic velocity of brown coal can not be followed by its hydrogenation velocity. That weighing heavy is decelerated and accelerated by addition with the catalyst and CLB (Coal Liquid Bottom), respectively. 3 refs., 5 figs.

6570 (FSJ–8901, pp. 163-166) **Short-contact-time pyrolytic liquefaction of coal.** Song, Chunshan (Osaka Univ., Faculty of Engineering, Osaka, Japan); Nomura, Masakatsu. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

As a result of investigating the contact pyrolytic mechanism of coal, the initial reaction was known to be closely related, also in the contact liquefaction of coal, with its contact pyrolytic behavior. By presuming, based on that knowledge, etc., that the pyrolytic type liquefaction reaction can be made in hydrogen donative solvent, without contact moreover nor use of gas phase hydrogen however with an effective utilization of coal pyrolysis, Wandoan subbituminous coal was studied in pyrolytic type liquefaction reaction with tetralin as solvent. As a result of obtaining the lightening in weight and differential temperature curve of Wandoan coal in the heightening process in temperature, 5^{0}C/min in nitrogen stream, it was known that the pyrolysis most frequently occurs under the temperature, 420 to 450^{0}C. As a result of making noncatalytic liquefaction of Wandoan coal under different conditions, the short-contact-time pyrolytic liquefaction reaction in nitrogen-tetralin series could obtain, though consuming hydrogen at an equal level to the low-temperature long-time reaction, a much higher conversion rate, 85.2 to 87.7%. 9 refs., 3 figs., 3 tabs.

6571 (FSJ–8901, pp. 167-170) **Supercritical extraction of Illinois No. 6 coal.** Miyamoto, Yukio (Osaka City Univ., Faculty of Engineering, Osaka, Japan); Ogo, Yoshiaki. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

The supercritical extraction liquefaction reaction, using methyl alcohol, was studied in reaction mechanism. A high pressure microflow reactor was used as a tester with Illinois No.6 coal as sample, together with Wandoan coal and Morwell brown coal for the comparison purpose. The liquefaction yield under 400^{0}C by 20MPa was equal in order to that of solvent hydrogenation by tetralin. Illinois No.6 coal during the liquefaction reaction gave out a bad smell, judged to be by possibly sulfide. In the supercritical extraction liquefaction with methyl alcohol solvent, preasphaltene, heavy in molecular weight, largely decreased in produced quantity. The solvent, as, in the coal liquefaction, stabilizing the radical produced by the pyrolysis and, moreover, giving the ability to easily solve and extract the low molecular weight compound, originally contained in the high molecular skeleton structure, can be in expectation, not as a single kind of solvent but under form of mixed solvent, to be effective on the liquefaction reaction. 2 refs., 3 figs., 2 tabs.

6572 (FSJ–8901, pp. 171-174) **Heavy solvent recycle experiment on the liquefaction of Yallourn coal.** Sato, Yoshiki (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Yamamoto, Yoshitaka; Saito, Ikuo. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

For Australian Yallourn brown coal, regarded to necessitate solvent, high in hydrogen donativeness as compared with subbituminous coal, by testing, with an autoclave, the liquefaction reaction by the solvent recycling, the change in liquefaction ratio, and yield and composition of produced oil, in case of change in condition for the liquefaction and heavy solvent hydrogenation treatment, were studied. After primary liquefaction oil, containing heavy content obtained by filtering reaction product, with tetralin as starting solvent, was hydrogenated, its vacuum distillation distillate oil was used as solvent for the next liquefaction reaction. As a result of test, the liquefaction reaction conversion ratio at each number of recyclings gradually lowered at more than four in number of recyclings and indicated a different behavior from that of subbituminous coal in liquefaction reaction. Different product yields, apart from the gas production ratio which slightly heightened with the proceeding with recycling, were known hardly to be different in reaction condition. Produced oil and solvent-refining coal largely changed in yield, by whether or not there was a hydrogenation treatment process. 1 ref., 3 figs., 1 tab.

6573 (FSJ–8901, pp. 175-178) **Coal liquefaction using a laboratory scale C.S.T, reactor (6). Analysis of effect in hydrogen flow rate on coal conversion.** Omori, Takao (National Chemical Lab. for Industry, Tsukuba, Japan); Kawamura, Mitsutaka; Oshima, Satoshi; Kuriki; Yasunori; Yumura, Motoo. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

In order to keep long-term stabilized operation in a coal liquefaction plant, adequate determination of feed ratio of H_2 and coal slurry and linear velocity, is an important subject. Limiting flow ratio of H_2 and coal slurry of which liquefaction rate increases with increase of H_2 feed rate and smooth operation can be carried out, is clarified in this report. A velocity equation on liquefaction accompany with evaporation of the solvent was proposed. The velocity equation was obtained from mean retention time of coal slurry which considered evaporation of the solvent and velocity constant which defined on this mean retention time. A equation for determination of feed ratio of H_2 and coal slurry, which secure long-term stabilized operation of the liquefaction plant, was proposed. In vapor-liquid equilibrium system with complete mixing in the reactor, it is important to determine the feed ratio of H_2 and coal slurry so as to prevent to be evaporation type. 7 refs., 7 figs., 1 tab.

6574 (FSJ–8901, pp. 179-182) **Change of hetero compounds distribution in recycle solvent on the liquefaction of battle river coal.** Yamamoto, Yoshitaka (National Research Inst. for Pollution and Resources., Tsukuba, Japan); Kamo Toru; Inaba, Atsushi; Saito, Ikuo; Sato, Yoshiki. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

In the process where hetero compound in coal liquefied oil is eliminated as water, ammonia, etc. by the hydrogenation dehetero reaction, valuable hydrogen is considerably consumed. In this study, Battleriver coal in the liquefaction reaction being made in composition analysis of hetero compound in residual recycling solvent, what kind of hetero compound was concentrated by the recycling was investigated, through investigating each hetero compound in change in relative concentration. Also based on that investigation, each nitride was studied in reactiveness and reaction mechanism of the hydrogenation and denitrogenation. Each nitride in residual recycling solvent for Battleriver coal was investigated in change in composition, by a GC using an NPD detector. As a result, nitride was respectively largely different in reactiveness, while dissoluble hetero compound was judged to gradually accumulate in recycling solvent. 3 refs., 3 figs., 2 tabs.

6575 (FSJ–8901, pp. 183-185) **Hydrogenation of the solvent for coal liquefaction (4).** Hayamizu (National Chemical Lab. for Industry, Tsukuba, Japan); Kikuo; Omori, Takao; Kawamura, Mitsutaka; Kuriki; Yasunori; Yumura, Motoo; Oshima, Satoshi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Coal liquefied product largely comprises, polar compound, apart from hydrocarbon, of nitride, oxide, etc., and hetero compound. It is important to study the behavior in the hydrogenation process, in case of using that product as recycling solvent, and, moreover, influence on and behavior in the liquefaction reaction. In this report, basic, acidic and other contents in liquefied product were studied in behavior. The basic content lowered with the lengthening in reaction time at each of all temperatures. And that lowering remarkably increased also with the heightening in reaction temperature. Its residual content mainly contained basic nitride, of which the lowering in content resulted from the occurrence of desorption from basic content, by the debasic reaction of nitride. Neutral polar compound at 350^{0}C was always low in lowering velocity, though the equilibrium reaction ratio was presumed to exist. While acidic compound was expected to be comparatively high in it, with an equilibrium reaction ratio of about 20% as calculated. 4 refs., 4 figs., 1 tab.

6576 (FSJ–8901, pp. 186-189) **Evaluation method of coal liquefaction characteristics.** Kawamura, Mitsutaka (National Chemical Lab. for Industry, Tsukuba, Japan); Kuriki, Yasunori; Oshima, Satoshi; Yumura, Motoo; Wakabayashi, Katsuhiko. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

In direct liquefaction technology of coal, an evaluation of liquefaction characteristics of different coal rank is very important for selection of liquefaction conditions and control of liquefaction process. In this report, various conditions were examined to evaluate liquefaction characteristics further quantitatively, and an evaluation method was studied together with clarification of necessary conditions for the evaluation. In a comparison of coal liquefaction characteristics, it is insufficient to make the comparison of liquefaction rate in the same reaction, the comparisons under extensive liquefaction conditions are required. In order to compare the liquefaction rates due to the difference of reactor types of liquefaction and reactor operation methods, it is necessary to obtain velocity parameters. The figures of X_p versus x_B, X_H versus X_B (X_i = liquefaction extraction rate, i =p, B, H), are probably to be one of methods which express coal liquefaction characteristics. As a result of investigation on the effect of coal rank using Prasad model, it is considered that Prasad model is not effected around X_p = 1. 3 refs., 6 figs.

6577 (FSJ–8901, pp. 190-193) **Study on the modeling of coal liquefaction.** Yumura, Motoo (National Chemical Lab. for Indsutry, Tsukuba, Japan); Oshima, Satoshi; Kuriki, Yasunori; Hayamizu, Kikuo; Omori, Takao; Kawamura, Mitsutaka; Wakabayashi, Katsuhiko. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

The model by C.N. Prasad et al was studied in adoptability to the initial liquefaction process by the short contact time liquefaction reactor. Then by using the Bimodal silica gel column/pyridine solvent SEC method, effective on the molecular weight distribution measurement of asphaltene and preasphaltene, the model by C.N. Prasad et al was studied in adoptability with an investigation on the molecular weight distribution of asphaltene and preasphaltene. In the initial process of coal liquefaction, preasphaltene is different between both the reactions of production and dissipation, and not able to be indicated by the molecular weight distribution model. The velocity-deduced analysis developed by Prasad, Shirozuka et al, though creating a new phase to the velocity-deduced analysis of coal liquefaction reaction, does not specify the individual element reaction for the reaction mechanism. Contrary to it, the reaction analysis, based on the conventional solvent lamping, has had regard to the elucidation of reaction mechanism. Both those analyses express an important profile of coal liquefaction reaction having a many-sided face. 8 refs., 4 figs., 1 tab.

6578 (FSJ–8901, pp. 195-197) **0.1 ton per day BSU operation for NEDOL process. Liquefaction behavior of various coals.** Saegusa, Hitoshi (Mitsui Engineering and Shipbuilding Co., Ltd., Tokyo, Japan); Hashimoto, Takao; Tsukui, Yutaka; Matsuo, Kazuyoshi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

As a part of technology development on bituminous coal liquefaction promoted by NEDO, liquefaction experiments of five kinds of coal were conducted in fiscal 1986 using a 0.1 ton/d bench-scale unit (BSU) installed at Mitsui Engineering and Shipbuilding. As the results of the experiments, the followings were reported: operating conditions in each process, variations with time of the equilibrium with solvent circulation, and liquefaction behaviors and material balances of each coal rank. Five kinds of coal used in the experiments were Wandoan, Illinois, Wyoming, Battle river and Taiheiyo coal. In any cases of five coals, stabilized total-processes circulation-operations could be performed. The oil (bp below 350^{0}C) yield of 50 wt% (daf basis) or above, which is a target of NEDOL process, was realized. In coal liquid distillation, fractions with boiling point of below 538^{0}C were obtained. Though the difficulty of draw of the residues depends on the coal rank, the properties of residue were as follows: softening point 180^{0}C or above, ash content 30 wt% or above. 4 figs., 3 tabs.

6579 (FSJ–8901, pp. 198-201) **Studies on the properties and composition of sediment and cokes in a 0.1t/d coal liquefaction reactor.** Narita, Hideo (Government Industrial Development Lab., Hokkaido, Sapporo, Japan); Shiraishi, Minoru; Maekawa, Yosuke. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

A 0.1 ton/d coal liquefaction test plant is being operated by Government Industrial Development Laboratory Hokkaido under the Sunshine Project. The properties and composition of sediment and cokes in the coal liquefaction reactor were analyzed in this study. The ash content of cokes in the reactor was little at wall side, and as a result of receiving heat hysteresis, some minerals were suffered transition or decomposition. The ash content of sediment in cone of the reactor was high level, and high contents of α-quartz and other calcium compounds such as calcite, anorthite were found in the ash, the content of iron sulfide was relatively little. Relatively developed laminate structure was found in coking products. Since mosaic texture was found even in Taiheiyo coal, it can be estimated that the products had fluidity when they were in the condition of coking. A negative correlation is shown between H/C and SI, it is thought that coking-carbonization proceeds along with dehydrogenation. 2 refs., 2 tabs.

6580 (FSJ–8901, pp. 202-205) **Studies on the gas hold up measurement using a coal liquefaction bench plant.** Narita, Hideo (Government Industrial Development Lab., Hokkaido Sapporo, Japan); Hasegawa, Yoshihisa; Kotanigawa, Takeshi; Yokoyama, Shin'ichi; Yamamoto, Mitsuyoshi; Yoshida, Tadashi; Fukuda, Takashi; Idogawa, Kiyoshi; Hirama, Toshiaki; Suzuki, Satoshi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Among various elementary technologies consist of a coal liquefaction process, it is a very important matter to elucidate the fluid characteristics of vapor-liquid-solid three phase, for the design of a coal liquefaction reactor. In this study, the gas hold up measurement using a 0.1 ton/d coal liquefaction bench plant was studied under the conditions of high temperature and high pressure using anthracene freed from crystal and creosote. Gas density increases with the increase of temperature, and tends to approach the value of pure hydrogen with the increase of space velocity. Liquid density decreases with the increase of temperature, and it has continuity with measured value under atmospheric pressure at room temperature. In the range of space velocities of 0-3 cm/s, the gas hold up values increase almost linearly. And in the preheating reactor, it is

estimated that the gas hold up values center around 0.7 with the increase of space velocity. 5 refs., 5 figs., 2 tabs.

6581 (FSJ–8901, pp. 210-212) **Synergistic effect of carbon disulfide-N-methyl-2-pyrrolidone mixed solvents on swelling of coals.** Osuga, Hironori (Tohoku Univ., Sendai, Japan); Iino, Masashi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

It had already been reported that carbon disulfide-N-methyl-2-pyrrolidone (MP) mixed solvent gives a high extraction ratio at the room temperature to bituminous coal. In this study, by presuming the coal swelling to influence the extraction ratio and measuring the swelling of residual coal with carbon disulfide-MP mixed solvent, the extraction mechanism by the mixed solvent was studied. Further, a study of coal in high molecular structure was tried. The heightening in extraction ratio of mixed solvent is influenced by the coal swelling with it. Coal, with the heightening in its extraction ratio, enlarges in swelling and diminishes in bridged concentration with it. But Zao Zhuang coal, though high in extraction ratio, is excessively low in swelling value and, however, was heightened in it when coal, larger than 1.35 in specific gravity, was removed, as judged to be abundant in inertinite. While the ratio between the swelling value with mixed solvent and that with MP, and extraction ratio with mixed solvent were known to be in a good correlation. 2 refs., 4 figs., 1 tab.

6582 (FSJ–8901, pp. 206-209) **Effect of the particle sizes on solvent extracts in coal.** Yazawa, Toshitaka (Nihon Univ., College of Science and Tech., Tokyo, Japan); Mashimo, Kiyoshi; Wainai, Toru. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Tadung coals were comminuted to four kinds of grain sizes, the effects of coal particle sizes on n-alkanes and straight-chain fatty acids were examined among relatively low molecular compounds, investigating the yields of solvent extracts and the composition distributions of straight-chain aliphatic compounds. Deashing treatment by hydrochloric acid was conducted using the coal residues after solvent extraction, then the effects of particle sizes on the deashing treatments of humins were studied through the variations of ash content in before and after of the treatments and the yields of fatty acids extracted after the treatment. It was found that there were differences in the carbon number distributions of straight-chain fatty acids and alkanes contained in respective particle sizes, through variations of the constituent ratios due to the maceral hardness difference. through the deashing rates by acid treatment of humin and the yields of pyridin extracts from deashin humin, it was also found that inorganic compounds, which are not concerned in formation of salts with fatty acids, increassed with shrinkage of the particle sizes. 4 refs., 7 figs.

6583 (FSJ–8901, pp. 217-220) **Study on the relationship between swelling and liquefaction of coal.** Amemiya, Kazuyoshi (Science Univ. of Tokyo, Faculty of Science, Tokyo, Japan); Kodama, Masaya; Esumi, Kunio; Meguro, Kenjiro; Honda, Hidemasa. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

The relationships between swelling and liquefaction of Taiheiyo coal and Yallourn coal were studied using mixed solvent of 1,2,3,4-Tetraphydroquionoline (THQ), ethanol and methanol with various mixing ratios. In Taiheiyo coal, the swelling ratio with THQ solvent only was 1.36, and that with 10 wt% addition of ethanol and that with 40 wt% addition of methanol was 1.58 maximum and 1.62 maximum, respectively. In Yallourn coal, the value with THQ only, that with 30 wt% ethanol and that with 30 wt% methanol was 1.19, 1.69 maximum and 1.63 maximum, respectively. As for the liquefaction conversion ratio of swelled coal, in Taiheiyo coal, the value with THQ only, that with 20 wt% ethanol and that with 50 wt% methanol was found to be 78%, 87% and 88%, respectively. And in Yallourn coal, the value with THQ only, that with 40 wt% ethanol and that with 40 wt% melhanol was found to be 77%, 81% maximum and 82% maximum, respectively. 6 figs., 1 tab.

6584 (FSJ–8901, pp. 221-224) **Simulation of swelling of coal particle bed and slurry viscosity during liquefaction.** Deng, Chao-Ran (Hokkaido Univ., Faculty of Engineering, Sapporo, Japan); Sanada, Yuzo; Chiba, Tadatoshi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

It had been elucidated that preasphaltene, if accumulated on the coal particulate surface, produced at the initial stage of coal liquefaction reaction, heightens the inter-particulate cohesive force and slurry viscosity, and that the viscosity of Akabira coal/creosote oil slurry corresponds to the swelling and contraction of coal particulate bed. In this study, by using a model of nucleus having not reacted yet, the coal particulate bed was analyzed in swelling velocity. The heightening in swelling ratio of Akabira coal particulate bed, during the heightening in temperature measured under the liquefaction condition, can be indicated by the model of nucleus having not reacted yet in regard to one particle of it. In that case, the relaxation activation energy is about 17Kcal/mol and almost equal to that to unbind the hydrogen bond. Its frequency factor depends upon the solvent. And, the diffusion activation energy is about 5Kcal/mol. The swelling with a low heightening velocity in temperature must be relaxation controlled, while that with a high heightening velocity in temperature must be regarded in both diffusion and relaxation processes. 3 refs., 4 figs., 1 tab.

6585 (FSJ–8901, pp. 225-228) **Desulfurization and demineralization of coal by molten alkali hydroxides.** Kusakabe, Katsuki (Kyushu Univ., Faculty of Engineering, Fukuoka, Japan); Orita, Masafumi; Morooka, Shigeharu; Kato, Yasuo; kusunoki, Koichiro. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Desulfurization and demineralization of Miike coal by molten alkali bath method were conducted, the optimum treating conditions were investigated measuring the removal ratios of ash, sulfur and heating value. Furthermore, for another four kinds of coal, their desulfurization and demineralization characteristics were examined. Next alkali solution was impregnated into Illinois coal, after heating treatment in nitrogen stream, then the relation between the removal ratios of sulfur, ash and alkali content of the coal was examined. In molten bath method, NaOH and KOH were molten in a crucible in nitrogen atmosphere then raw coal was put in that and was stirred. The removal ratios of sulfur, ash of five kinds of coal after one hour molten alkali treatment, were about 90% or above. Increasing temperature caused a heightening in the removel ratio of sulfur, but heating value was lowered. Under the optimum treating conditions in impregnation in alkali solution, the removal ratios of sulfur and ash of Illinois coal were 88% and 99%, respectively. These results close to those of molten alkali bath method. Heating value of treated coal with 43 wt% alkali content was 7.5 Mcal/kg-db, it was higher than that (7.3 Mcal/kg-db) of molten alkali bath method. 1 ref., 3 figs., 1 tab.

6586 (FSJ–8901, pp. 241-244) **Simulataneous graphic representation of the chemical shift ranges for various coal liquids.** Hayami, Kikuko (National Chemical Lab. for Industry, Tsukuba, Japan); Yanagisawa, Masaru; Kuriki, Yasunori; Yumura, Motoo; Kawamura, Mitsutaka. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Simultaneous graphic representation of the chemical shift ranges of 1H and 13CNMR was studied for the component analysis of coal liquids. The spectrum's partial structures and the chemical shift ranges of important pure compounds in coal liquids were clarified. The partial structures of the side chain were classified into methyle, methylene, methyne groups and a naphthene ring, and the chemical shift ranges were represented in graphics. The chemical shift ranges of aromatic hydrocarbon of coal liquids were also represented in graphics in correspondence with aromatic area signals. In the aromatic area of 13CNMR, a signal of quternary is given on the low magnetic field, and the signal of carbon bonded with proton is given on the high magnetic field. In the aromatic area of 1HNMR, when the size of the condensed ring is increased, the chemical shift

moves toward the low magnetic field; this is contrary to the tendency of 13CNMR. When substituted by nitrogen or oxygen, the shift ranges of both 1H and 13CNMR are widened greatly, and so N and O can be detected easily. 4 figs.

6587 (FSJ–8901, pp. 245-248) **Chemical structure analyses of hydrocarbon compound classes of coal-derived oil for prediction of their densities.** Sato, Masaaki (Hokkaido Univ., Faculty of Engineering, Sapporo, Japan); Nemoto, Hirofumi; Yokoyama, Susumu; Sanada, Yuzo. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Coal-derived oil was classified into hydrocarbon compound classes by high power liquid chromatography, and a structure analysis method to represent each class by several kinds of atomic groups was studied. Sample was solvent cut of Wandoan coal-derived oil. The bond types of hydrogen were analyzed and classified by 1HNMR in each compound class. The bond types of carbon was divided into aromatic and aliphatic groups by 13CNMR. And based on the above, the contents of carbon and hydrogen were obtained for each bond type. A relational expression to indicate each chemical compound class by seven atomic groups and their contents was introduced, and the content of each atomic group was calculated from the contents of carbon and hydrogen obtained by NMR and the element analysis value. This reflects the chemical structure of each chemical compound class. There is a good correlation between the molality (n_i) and the specific volume V of an atomic group, and the value of the partial molality (v_i) is inherent in the atomic group. Ni value was obtained from the structure analysis of each chemical compound class classified by high power liquid chromatography, and the density of each chemical compound class was predicted using vi of each atomic group, which coincided well with the measured value. 2 figs., 2 tabs.

6588 (FSJ–8901, pp. 249-252) **Structural analysis of pyridine-soluble materials from reductively hydrogenated Yubari Coal.** Kurio, Takuya (Osaka Univ., Faculty of Engineering, Osaka, Japan); Miyake, Mikio; Nomura, Masakatsu. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

The structue of reductively hydrogenated material of Yubari coal was studied. After anionizing the coal using THF and melting metal K, hydrogenated coal was obtained by adding methanol. This was extracted by hexane, benzene, and pyridine solvents. The H/C ratio of hydrogenated coal increased by 0.23% compared with that of raw coal. And the entire solubility in solvents was 65.9%, an increase of 42.6% over raw coal. By hydrogenation the frame of the flat surface of the aromatic ring collapsed, and so it became easier to detect the alkyl side chain by FT-IR compared with raw coal. Hexane soluble 72% is the methanol eluted polarity component, and there was a naphthene ring by partial hydrogenation of the aromatic ring. And the existence of phenanthrene and biphenyl classes was also conjectured. The molar weight is usually around 350, and some are more than 600. At present, classification according to the molar size by GPC and analysis are being carried out. 4 refs., 9 tabs.

6589 (FSJ–8901, pp. 253-256) **Structural analyses and thermal stabilities of coal liquid vacuum residue produced from a Brown Coal.** Mochida, Isao (Kyushu Univ., Fukuoka, Japan); Yufu, Atsushi; Sakanishi, Kinya. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Structure and thermal stability of coal liquid vacuum residue (CLVR) produced from brown coal was studied. Sample was two kinds of CLVR (M1 and M2) of Morwell coal. Composition and structure of CLVR are changed with the progress of primary liquefaction reaction, and the yield of soft components like oil and asphartene are increased and the yield of heavy components is decreased. On the other hand, polarity components originated from heavy components are converted or mixed into soft components, and molecular weight and the content of oxgen-containing group are increased. Therefore, liquefaction conditions which keep the compositional and structural changes of circulating solvents and CLVR minimum are required. According to the study of transportation and storage stabilities of the two kinds of CLVR at 300 and 350°C; under nitrogen draft, softening progressed due to thermal decomposition and at the same time the components became heavier (dehydrogenation reaction.) Even from nitrogen filled and sealed system experiments it was found out that temperature and residence time are important for stability. It is more hard for M2 to become heavy than M1. M1 has little naphthene group in the soft components, little hydrogen donorability, much alkyl group and oxygen-containing group, shows radical reaction easily, has much ash content, is hard to depolymerize; and so it has low thermal stability. 2 figs., 4 tabs.

6590 (FSJ–8901, pp. 257-260) **Liquefaction of victorian Brown Coal (7).** Hirano, Tatsuo (Kobe Steel, Ltd., Tokyo, Japan); Okuma, Osamu; Tachibana, Shigeo; Saito, Kaizaburo; Nakako, Yukio. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

In the brown coal secondary liquefaction, oil separation from hydrogenation product and recycled circulation of solvents are executed in the distillation process, and the distillation conditions influence the whole process. Bottom circulation, and the thermal decomposition of the bottom by primary hydrogenation conditions and distillation were studied. From the Morwell coal-derived liquid, distillated bottom was recycled at the bottom temperature of from 287 to 350°C. The bottom (CLB) yield decreased with the rise of the distillation temperature. With the bottom circulation the CLB yield is greater than that with only the solvent circulation of the distilled oil. This is because with the former, HS of CLB is hard to be distilled even when the distillation temperature is raised. That means that characteristics of produced CLB and also the thermal behaviors under the CLB distillation conditions differ depending on whether bottom circulation is applied or not. Without bottom circulation, when the distillation temperature is raised to 350°C to improve the oil yield, CLB becomes heavier and this is disadvantageous. With bottom circulation (CLB circulation in particular), on the other hand, when the distillation temperature is raised, CLB is softened and the improvement of oil yield is expected for. 3 refs., 4 figs., 3 tabs.

6591 (FSJ–8901, pp. 261-263) **Characteristics of tars from coal liquefaction residues.** Furuta, Takashi (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Maruyama, Katsuhisa; Yamaguchi, Kiyoshi; Shiraishi, Minoru; Imuta, Kazutoshi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Characteristics of tars obtained through thermal treatment of coal liquefaction residues were studied. Samples were liquefaction residues of Wandoan coal, Illinois coal, and Morwell coal. Thermal treatment of residues was executed at the temperature-up speed of 5°C per minute with the last temperature 650°C, running N_2. Tar began to be distilled at 250°C and stopped at 600°C. The yields were different according to the samples, and the yield of every sample excluding one sample which contained much heavy oil distillate (yield was 30%) was 4-8% of the residue. Even with the same coal species, the tar yield was different depending on the liquefaction process and the residue separation method. O/C and H/C in the tar increased compared with the residue. The f_a value (aromaticity) was 0.63, lower than the 0.7-0.72 of the bituminous coal liquefaction residue. Average molecular weight was 200-260, and there were many aliphatic structures. In every tar, there was much heavy distillate of 350-538°C boiling point, and there was little light and medium gravity distillate of 100-350°C boiling point. In the tars there were soft and medium gravity contents which did not exist in the liquefaction residues, and this is the result of thermal decomposition. 5 tabs.

6592 (FSJ–8901, pp. 264-267) **Dynamic behavior of the forms of sulfur in the low-temperature hydropyrolysis of coal at high pressure.** Sugawara, Takuo (Akita Univ., Mining College, Akita, Japan); Sugawara, Katsuyasu; Enda, Yukio. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Five kinds of American noncoking bituminous coal which are different forms of sulfur were used to carry out hydropyrolysis for desulfurization. Hydropyrolysis was performed at conditions of hydrogen stream, 30kg/cm^2 and 500^{0}C. Organic sulfur decreases rapidly and transfers into gas and tar. Pyrite is reduced to ferrous sulfide. The reduction to metallic iron cannot be neglected for some kinds of coal. Nonisothermal simulation was carried out concerning the change of sulfur-form distribution with time by applying the dynamic model. Frequency factors on reaction were determined for all kinds of coal. Microscopic observation indicated that exinite was at first discomposed and disappeared during heating up and at the same time gaps or voids developed around the pyrite in vitrinite owing to the reduction of pyrite to ferrous sulfide. This reduction proceeded further to metallic iron with the time elasping. The relationships between change of frequency factors ratio and time-averaged internal surface area in heat-up period, releasing rate of organic sulfur into volatile matters, and exinite content in raw coal were determined. 6 refs., 9 figs., 5 tabs.

6593 (FSJ–8901, pp. 272-275) **Catalytic dealkylation of alkyl benzene and coal derived oils with steam.** Yamamoto, Mitsuyoshi (Government Industrial Development Lab., Hokkaido, Sapporo, Japan); Maekawa, Yosuke; Kotanigawa, Takeshi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Greater part of coal liquefied oil is composed of aromatics and steam was used in place of expensive hydrogen to reform through catalytic dealkylation. Raw material is a neutral oil of liquefied oil and toluene was used as the model. Prepared catalysts are mainly composed of Fe_2O_3 and NiO and partially $NiFe_2O_4$. It is desirablt that the demethylation of toluene with steam does not result benzene ring cleavage or disproprtination but methyl group is gasified with water gas shift reaction. Benzene yield becomes equilibrium when (R)=water/toluene is equal to or more than 6 but gas yield increases linearly with the increase of R. Gas products were H_2, CO, CH_4 and CO_2, and liquid product was only benzene, indicating that the disproportionation did not occur. Liquefied oil was used to the experiment, in which benzene ring holding rate was 70%, which was not so high. Alicyclic compounds of five-membered ring were cleaved easily, converting to the corresponding alkylbenzene but alicyclic compounds of six-membered ring were simply dehydrogenated and converted to aromatic compounds. 2 refs., 3 figs., 2 tabs.

6594 (FSJ–8902, pp. 4-6) **Study of the linear free energy relationship relating to coal liquefaction reaction.** Kawai, Satoshi (Nippon Brown Coal Liquefaction Co., Ltd., Tokyo, Japan); Kageyama, Yoichi. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Suppressing effect of decomposition due to solvent and polymerization rate of solvent without hydrogen donor were studied when tetrakosan(n-C_{24})was decomposed. Heating decomposes n-C_{24} but when hydrogen donor coexists, the decomposition is suppressed because the radical is captured and eliminated. Larger the decrease of free energy accompanied by the release of hydrogen from hydrogen donor solvent, larger the suppression of decomposition, and the logarithmic linearity for ΔG is realized. Coking reaction proceeded with the liquefaction in the high temperature coal liquefaction. Thermal polymerization rate was measured for solvents without hydrogen donating such as naphtalene and anthracene. Larger the heating value(ΔH) accompanied by polymerization(dimerization), larger the polymerization rate, and the plymerization rate constant showed the logarithmic linearity to ΔH. Concerning hydrogen transfer from the hydrogen donor solvent and coking prevention under the existence of hydrogen donor solvent at the brown coal liquefaction, the tendency can be known by using the change of free energy. 5 refs., 3 figs.

6595 (FSJ–8902, pp. 7-10) **Study on the modeling of coal liquefaction based on the SEC analysis.** Yumura, Motoo (National Chemical Laboratory for Industry, Tsukuba, Japan); Oshima, Satoshi; Kuriki, Yasunori; Hayamizu, Kikuo; Omori, Takao; Kawamura, Mitsutaka. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Asphaltenes(AS) and preasphaltenes(PAS) obtained by coal hydrogenation were again hydrogenated to study their molecular weight distribution and chemical structures. AS and PAS were hydroliquefied in tetralin solvent and at initial hydrogen pressure of 80kg/cm^2, and the residue obtained from THF solubles was used as the hydogenated sample. Molecular weight distribution was measured by a SEC equipment and absorption spectra at each elution time in UV chromatography and SEC were measured. The molecular weight distribution of PAS has two peaks and the peak of higher molecular weight was thought to be the associated molecules of polar group and disappeared with advance of hydrogenation. When oils obtained by AS hydrogenation were analyzed, long chain paraffins were much contained for Taiheiyo coal but were hardly contained in Morwell coal. Components of high molecular weight in AS from Taiheiyo coal contains the long alkyl chains which are desorbed and decomposed by hydrogenation. 7 refs., 5 figs.

6596 (FSJ–8902, pp. 11-14) **Studies on coal liquefaction (59). Hydrogen shuttling by aromatic hetercompounds.** Futamura, Shigeru (The Univ. of Tokyo, Faculty of Engineering, Tokyo, Japan); Koyanagi, Seiya; Kamiya, Yoshio. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

When 9-benzylphenanthrene was hydrogenolyzed, hydrogen shuttling ability of different aromatic compounds was compared. The performance of hydrogen shuttler is dominated by hydrogen accepting ability of shuttler itself and hydrogen donating ability of generated radical. When Sr(R) values(superdelocalizability values) of aromatics are paid attention, the additive effect on conversion rate due to hydrogenolysis reflects well the difference of Sr(R) values. On the hydrogen releasing process of radical, phenanthrene or phenanthridine system are more exthermic than anthracene or acridine system by 4-5kcal/mol, so that the former is more beneficial than the later as shuttlers from the energy viewpoint. As to hydrogenolysis of 9-benzylphenanthrene in tetralin at 430^{0}C reacting temperature, aromatic compounds containing nitrogen have higher shuttling abiiity and the phenanthridine was most effective. Optimal mixing ratio of hydrogen donor to hydrogen shuttler was 5:1. 3 refs., 1 fig., 2 tabs.

6597 (FSJ–8902, pp. 15-18) **Influences of low-pressure hydrogen and deashing pretreatment on the hydrogen transfrring liquefaction of brown and sub-bituminous coals.** Mochida, Isao (Kyushu Univ., Fukuoka, Japan); Sakata, Ryuji; Sakanishi, Kinya. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

The liquefaction of coals was studied at the condition of high rate heating up, hot temerature-short contact time and solvent/coal ratio=1.5:1 by using tetrahydrofloranthen which is high hydrogen donor solvent. Morwell brown coal (M coal) and Taiheiyo coal(T coal) which are different degree of coalification, were used. Deashing was conducted with 10% methanol/1N hydrochloric acid. Both coals are suggested that the solvent/coal ratio could be decreased to 1.5:1 and M coal was greatly affected by the reduction of solvent ratio, so that gas yield increased and oil plus asphalthene(AS) yield decreased. T coal showed the remarkable reduction of oil yield. Deashing pretreatment at lower solvent/coal ratio showed effects for M coal to suppress gas generation, and to reduce the preasphaltene (PAS) and residue yields; and improved the oil yield through AS reduction but increased PAS and gas yields for T coal. It is necessary to control the high decomposing property for brown coal and excessive hydrogen consumption results the increase of gas yield on the contrary. The initial hydrogen pressure of 20 atm. is suitable for both coals. 3 refs., 4 figs., 1 tab.

6598 (FSJ–8902, pp. 19-22) **Effects of some polyhydrogenated solvents and deashing pretreatment in the hydrogen transferring liquefaction of Morwell brown coal.** Mochida, Isao (Kyushu Univ., Fukuoka, Japan); Takayama, Akihisa; Sakanishi, Kinya. Fuel Society of Japan, Tokyo (Japan). 10 Nov

1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

The reduction of solvent/coal(SC) ratio is important from the viewpoint of the reaction volume efficiency, so that the liquefaction with poly-hydrogenated solvents was stuidied to reduce SC ratio to 1:1. Octahydroanthracene (8HA), dodecahydrotriphenylene(12HTp) and hexahydro-anthracene(6HA) were used as solvents. Liquefaction yield was not remarkably improved compared with conventional tetrahydrofluoranthen(4HFL) in case of 1:1 SC ratio. This was caused by the fact that the timing between coal hydropyrolysis and hydrogen transfer from solvents did not agree and hydrogen donating efficiency to radical was inferior. Further solvent recovery rate was lower owing to disproportionation between solvents and isomerization. The suppression of coal swelling and dispersion becomes insuffucient by lowering SC ratio to 1:1. It is necessary to operate at higher temperature to increase the dehyrogenation rate of 8HA or to mix 4HFL to get higher liquefaction yield by using 8HA which shows lower dehydrogenation rate than that of 4HFL. At the condition of 1:1 SC ratio, the product became heavier and liquefaction yield became lower by deashing pretreatment. 1 ref., 3 figs., 2 tabs.

6599 (FSJ–8902, pp. 23-26) **Effect of preheat treatment on coal liquefaction.** Inukai, Yoshinari (Government Industrial Research Inst., Kyushu, Saga, Japan); Arita, Seiji. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

The effect of preheat treatment on coal liquefaction was studied. In case of Wandoan coal to which HAO(hydrogenated anthracene oil) solvent was used, preheat treatment at 250-350^{0}C showed a effect to proceed liquefaction at 350^{0}C. But in case of liquefaction at 400^{0}C or more, preheat treatment did not show any effect because the preasphaltenation proceeded sufficiently only by the liquefacting condition. When AO(anthracene oil) solvent was used, preheat treatment showed a effect for 400^{0}C liquefaction, especially, pyridine insolubles were least at 250^{0}C preheat treatment. For 450^{0}C liquefaction, the effect of preheat treatment did not appear because of the high temperature. In case of Illinois coal using HAO and AO solvents, preheat treatment up to 350^{0}C did not show a effect for 400^{0}C liquefaction. In case of Lingan coal using HAO solvent, preheat treatment of 250-350^{0}C showed a effect for 400^{0}C liquefaction. Preheat treatment at 350^{0}C showed a effect for AO solvent and 400^{0}C liquefaction. 3 refs., 9 figs., 1 tab.

6600 (FSJ–8902, pp. 27-30) **Interaction between coal and hydrogen donor solvent in a preheater (5). Study by nmr.** Adachi, Yoshio (Government Industrial Research Inst., Kyushu, Saga, Japan); Shibata, Masao; Sakaki, Tsuyoshi; Miki, Toshiharu; Arita, Seiji. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

NMR measurement was carried out on the product (filtrate) which was obtained by the heat treatment of anthracene hydride oil slurry of various kinds of coal under preheating conditions using a pipe-type quick-heating equipment, the extraction in the temperature-up process, and the removal of the residue coal and the residue ash; and the problems in studying the initial reaction of liquefaction were investigated. In Illinois coal and Wandoan coal, with the rise of the sampling temperature and the decrease of the toluene insoluble matter ratio, the f_a of the residue coal obtained by the solid high resolution NMR increased; and that leads to the fact that the component with high f_a does not dissolve and remains as liquefaction residue. The f_a value of the Wabamun coal is high despite its low coal rank, and the coal did not show much change even when the toluene insoluble matter ratio decreased. According to the ratios of hydrogen types obtained by the ^{1}H.NMR of the filtrate, with the rise of the sampling temperature, the ratio of the aromatic hydrogen increases in all three kinds of coal. 3 refs., 4 tabs.

6601 (FSJ–8902, pp. 31-34) **Hydrogenolysis reaction of deashed coal with tetralin.** Okajima, Takeyoshi (Nihon Univ., College of Science and Tech., Tokyo, Japan); Kiho, Mariko; Yamamoto, Tadahiko; Mashimo, kiyoshi; Wainai, Toru. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Hydrogenolysis reaction with tetralin was carried out on the coal deashed through highly efficient acid treatment and on the untreated coal. And the reactivity difference between the two was studied by their invert ratios, the yield changes of the liquid products and the analysis of the liquefied oils. As deashing treatment, the sample coal pulverized into 60-200 meshes was treated by 2.8 mole hydrochloric acid agitaing and bathing at 70^{0}C and then treated by rich hydrofluoric acid and 5.7 mole hydrochloric acid in turn. Following results were obtained by the experiment: In the hydrogenolysis reaction of Taiheiyo coal, the invert ratio, the yield of the liquefied products and the yield of alkane in HS increase by the deashing treatment; in the hydrogenation reaction of Alabama coal, there was hardly any effect of deashing treatment; the influences the ash content exerts on the coal liquefaction reaction are various and they depend on the composition of the ash content and on the coal rank. The existence of the ash content is considered an important factor for the improvement of the reactivity. 6 refs., 2 figs., 1 tab.

6602 (FSJ–8902, pp. 35-38) **Behavior of gaseous hydrogen in coal liquefaction mechanism.** Horimatsu, Toshiyuki (Tokyo Univ. of Agriculture and Tech., Faculty of Engineering, Tokyo, Japan); Kimura, Ken'ichi; Ueda, Kohei; Funatsu, Eiji; Kabe, Toshiaki. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Behavior of gaseous hydrogen in coal lifquefaction mechanism was studied using tritium as a tracer. Datong coal (bituminous coal) and Morwell brown coal were pulverized into less than 150 meshes and after drying under reduced pressure, the sample coal and tetralin were charged in an autoclave. Hydrogen labelled by tritium was introduced and after reaction, products were separated by filtration, THF extraction and distillation, and the amount of the radio activity was measured. The ratio in the coal of the hydrogen atom which interchanged with gaseous hydrogen calculated from the tritium concentration at 300^{0}C is about 8.5at %, and it is considered that the hydrogen with weak bonding power like function group interchanges with gaseous hydrogen. As a result of simulating the tritium concentration using a hydrogen interchange model assuming that tritium migrates only by hydrogen interchange, it was found out that the hydrogen interchange rate constants of both Datong coal and Morwell brown coal are about ten times as high as those of solvents. 6 refs., 4 figs., 1 tab.

6603 (FSJ–8902, pp. 39-42) **Solvent extraction of coal on supercritical condition.** Miyamoto, Yukio (Tosoh Corp., Tokyo, Japan); Ogo, Yoshiaki; Hirota, Naohiko. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

In the elementary process of solvent hydroliquefaction reaction without using hydrogen gas, the existence of a process which does not consume hydrogen was confirmed. It was assumed that this is the process in which low molecular weight compound included in the crevice of high polymer chain is extracted by solvents, and the propriety of the assumption was studied by changing the solvent to a hydrogen non-donor solvent of supercritical condition. As a result of classifying the liquid products of Illinois No. 6 coal extracted by each solvent, it was found out that the yield of THF soluble matter is higher with a solvent of higher hydrogen donorability and solubility. In the benzene soluble matter, the yield of tetralin is high and the yield of methanol is low. The yields of the toluene-tetralin mixed agent and the toluene extraction were almost the same. From the above results, it was found out that the free radical generated by thermal decomposition of the coal liquefaction reaction is donated hydrogen mostly by solvents, and on the other hand, most of the benzene soluble matter is liquefied regardless of the hydrogen donated by solvents. 6 figs., 2 tabs.

6604 (FSJ–8902, pp. 43-46) **Effect of addition of tarsand bitumen to recycle solvent on the liquefaction of Taiheiyo-coal.** Saito, Ito (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Yamamoto, Yoshitaka; Kamo, Toru; Inaba, Atsushi; Miki, Keiji; Sato, Yoshiki; Imuta, Kazutoshi. Fuel Society of

Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

This report aims as investigating the yield changes of liquefied products brought about when recycles are repeated by adding bitumen little by little to recycle solvents. Using a mixed solvent in which 10% bitumen is added to tetralin as an initial solvent, Taiheiyo coal was liquefiefied, 10% tarsand bitumen was added every time to the recycle solvent thus obtained, and this was repeatedly recycled. An experiment (A method) to use the solvent, obtained by removing residue by reduced pressure distillation from the slurry after liquefaction, as recycle solvent after hydrotreatment, and an experiment (B method) to use by recycling the distilled oil, obtained by filtrating the slurry after liquefaction, hydrotreating the filtrate and by reduced pressure distillation, were conducted. According to the experiment results, the invert ratio and the characteristics of SRC and solvents do not change rapidly with the increase of the recycle number. By B method, not only is the decrease of the invert ratio due to the recycle number suppressed but also the solvent yield is increased and higher liquefaction oil yield can be counted upon than that by A method. 3 refs., 6 figs., 1 tab.

6605 (FSJ–8902, pp. 47-50) **Effect of solvent recycle on coal liquefaction using small scale continuous flow unit.** Inaba, Atsushi (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Yamamoto, Yoshitaka; Kamo, Toru; Miki, Keiji; Sato, Yoshiki. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

While heavy fraction is recycled in the NEDOL process of bituminous coal liquefaction and in the BCL process of brown coal liquefaction, this report aims at studying problems in solvent recycle operation using a small-scale continuous-flow type coal liquefaction unit. Solvent recycle operation was executed using Yallourn coal at the reaction temperature of 450^{0}C and at the reaction pressure of 250kg/cm^{2}G. The hydrogen flow rate was kept constant regardless of the recycle number, but the rate of solvent against coal was kept 2 in the first and second recycles, and 4 after the third recycle. As a result of experiments, it was found out that the liquefaction reaction speed of Yallourn coal is fast and the invert ratio of the THF insoluble matter is more than 80% regardless of the recycle number, and that the yield of the THF soluble and toluene insoluble matter and its characteristics are constant regardless of the recycle nunber. The softening speed of the toluene soluble and hexane insoluble matter is slow and the toluene soluble and hexane insoluble matter is increased and the oil yield is decreased as the recycle number is increased. 3 refs., 2 figs., 4 tabs.

6606 (FSJ–8902, pp. 51-53) **Studies on the solvent in coal liquefaction (6).** Masunaga, Toshio (Mitsubishi Chemical Industries Ltd. Tokyo, Japan); Kageyama, Yoichi; Kaneko, Shinji; Kawai, Satoshi. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Solubility of solvents was studied in this report as a part of investigation on the influences solvents exert in coal liquefaction. Using model solvents (toluene and mixture of toluene/cyclohexane) of comparatively low boiling points and process naphtha, solubility at high temperature was studied. Producing CLB (Coal Liquid Bottoms) of different characteristics, the influences the characteristics of CLB exert on the solubility of solvents was also studied. Such solvent characteristics as the f_a value, the element analysis value, and the solubility parameter δ were studied, and the best correlation was observed between δ and DAO extraction ratio (recovery rate of CLB extraction). As a result of extracting CLB of different characteristics by toluene/cyclohexane (75/25) at 170^{0}C, a good correlation was observed between the δ of CLB and DAO extraction ratio, and there was a comparatively good correlation between the f_a value and DAO extraction rate. The solubility of coal liquids can, therefore, be expressed by δ, and the solubility of CLB can also be expressed by f_a. 1 ref., 4 figs., 1 tab.

6607 (FSJ–8902, pp. 55-57) **Studies on Brown Coal Liquefaction (3). Relationship between reaction condition and product properties.** Kaneko, Shinji (Asia Oil Co., Ltd., Tokyo, Japan); Watanabe, Masato; Kageyama, Yoichi; Kawai, Satoshi. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Properties of products obtained under various reaction conditions in the brown coal liquefaction reaction were studied and their relations with reaction conditions were investigated. Morwell coal and solvent were charged at maf/solvent = 1/3 in an electromagnetic-induction and rotation-agitation type autoclave with baffle, catalyst and simple substance of sulfur were added, and hydrogen gas was continuously blown in for the liquefaction reaction. The reaction temperature was 420-440^{0}C, the reaction pressure was 100-190kg/cm^2, and the reaction time was varied from the instant to 60 minutes. According to the experiment results, when the reaction pressure is reduced, the hydrogenation of the solvent is suppressed, and so in the initial reaction, hydrogen is insufficient for stabilizing radical and softening is suppressed. In the system added with much catalyst, when the reaction time is prolonged, the radical formation amount is decreased and hydrogenation progresses, and so softening progresses considerably. When the pressure is reduced furthermore, however, the partial pressure of hydrogen becomes extremely low and hydrogenation is suppressed, and so softening is also suppressed. 1 ref., 2 tabs.

6608 (FSJ–8902, pp. 58-60) **Hdyrogenation of the solvent for coal liquefaction (5). Effect of chemical compositions in solvent on coal liquefaction.** Kuriki, Yasunori (National Chemical Lab. for Industry, Tsukuba, Japan); Yumura, Motoo; Oshima, Satoshi; Hayamizu, Kikuo; Kawamura, Mitsutaka. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

How the polarity class included in solvents is related with and what influences it exerts on the coal liquefaction reaction were studied, especially on the quantity relation of the acid-basic class. Hydrogenation solvent and hydrogenation anthracene oil, products obtained by the recycle experiment of Taiheiyo coal by direct hydroliquefaction method, were used as solvent samples. The liquefaction reaction was batch type, used an autoclave, and the liquefaction conditions were within 100kg/cm^2 hydrogen initial pressure, 400-450^{0}C temperature and 120 minute reaction time. As a result of studying changes according to the reaction time in the liquefaction ratio and in the oil formation ratio at the temperature of 450^{0}C in the catalyst added reaction method, it was recognized that there was possibility enough that the difference in the polarity class content has something to do with the difference in the liquefaction reaction from the fact that the solvent without hydrotreatment attained a remarkably high liquefaction ratio at the initial reaction, and from the comparison of liquefaction ratio contributions between solvents. On the other hand, the oil formation ratio is suppressed lower in the solvent with more polarity class content. 4 refs., 4 figs., 1 tab.

6609 (FSJ–8902, pp. 61-63) **Composition change of solvent at 1 T/D PDU coal liquefaction plant.** Kawamura, Mitsutaka (National Chemical Lab. for Industry, Tsukuba, Japan); Kuriki, Yasunori; Oshima, Satoshi; Yumura, Motoo; Hayamizu, Kikuo; Niwa, Yoshio. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

The startup character of 1 t/d coal liquefaction plant was studied especially paying attention to the composition change of solvent, to clarify the dynamic behavior of NEDOL process. Samples were collected at different times from each sample collecting point at the plant startup, and their compositions, f_a values and distillation characters were analyzed. The character of the liquid product of Illinois No.6 coal from viewpoint of f_a is that when the component is lighter f_a is smaller, and so f_a can be a barometer to show the distribution of heavy and light components. The f_a change at the startup could not be observed clearly. As a result of analyzing the composition changes of solvent at the startup according to the types, it was found out that when the recycle number is about 10, the solvent composition has not reached the stationary state. Influences of

disturbance are surmised stronger in the solvent hydrogenation process than in the liquefaction process. 1 ref., 6 figs., 1 tab.

6610 (FSJ–8902, pp. 64-67) **Liquefaction of Victorian Brown Coal (8). Effects of vaporization of solvent on liquefaction reaction.** Yanai, Shun'ichi (Kobe Steel, Ltd., Tokyo, Japan); Okuma, Osamu; Hirano, Tatsuo; Saito, Kaizaburo; Matsumura, Tetsuo. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

In the reactor of the coal direct liquefaction process, a part of solvent migrates to the gaseous phase, changes the real residence time of slurry, and exerts great influences on the coal liquefaction yield. In this report, gas flow rate was taken up from among the factors that have something to do with the migration of solvent to the gaseous phase, the migration amount of the solvent to the gaseous phase was changed by changing the supplied gas flow rate using 0.1 t/d PDU with three-serial-vessel type reactors, and its influences were studied. The composition of the liquid extracted from each reactor and the composition and the flow rate of the formed liquid were measured, and the real residence time was presumed from the gas holdup value obtained by the cold model experiment. As a result, when the flow rate of the supplied gas was increased, the migration rate of the solvent to the gaseous phase increased and the oil yield was also increased. The migration amount of solvent to the gaseous phase changes according to the degree of softening, and accordingly the real residence time is changed; and as a result the oil yield and others are influenced. 2 refs., 7 tabs.

6611 (FSJ–8902, pp. 68-71) **Liquefaction behavior of Canadian Battleriver coal.** Hayakawa, Keiichi (Sumitomo Metal Industries, Ltd., Osaka, Japan); Kurachi, Kazuhito; Chikata, Tsukasa; Hirano, Katsumi. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

As a result of demonstrative operation by a NEDOL process of Canadian Battleriver coal, residue could not be smoothly extracted from the steam distillation tower. In order to solve that problem, by using an electromagnetic induction-agitated autoclave and laboratory scale continuation unit of 5l/h slurry treating coal liquefaction, Battleriver coal was basically studied in liquefaction behavior. As a result of experiment, residue produced from Paintearth raw coal (with 16% in ash content), included in Battlerier coal, was so high in viscosity as judged to be beyond the allowable limit of extracting pump from the steam distillation tower. While residue of deashed coal, 6% in ash content, was almost similar in properties to Wandoan and other coal, which degree in deashing treatment was judged to able to have residue smoothly extracted from the distillation tower. Vesta coal, easy to liquefy, was assumed to able to sufficiently achieve the target, higher than 50% in liquid yield, in the NEDOL method. 3 refs., 3 figs., 3 tabs.

6612 (FSJ–8902, pp. 72-75) **1 ton per day PDU operation for NEDOL process (2).** Ikari, Hidefumi (Sumitomo Metal Industries, Ltd., Osaka, Japan); Hayakawa, Keiichi; Echigo, Hiroyuki; Yamada, Takehiko. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

With Illinois No.6 coal (Riverking), upper limit coal and Battleriver coal (Vesta), one kind of lower limit coal in the design region of pilot plant in the NEDOL process, a process demonstration operation by a 1ton/d plant was made. As for sample raw coal, in order to prevent the blockage of slurry line by the mixing with foreign matter in case of Illinois coal and bad extraction of liquefied residue by the high ash content in case of Battleriver coal, coal, pretreated with waterwashing and deashing, was used in both the cases. Illinois No.6 coal was 47.8% in liquid yield at the upper limit PDU condition. However by estimating the liquid yield at the limit condition by NEDOL, a value in the vicinity of target value to be 50%daf was obtained. While Battleriver coal was 51.1% in liquid yield at the upper limit PDU condition. recycling solvent being generally equilibrated, Illinois and Battleriver coal were stabilized at about 35 and 31%, respectively, in heavy oil concentration before the hydrogenation. 1 ref., 3 figs., 7 tabs.

6613 (FSJ–8902, pp. 76-79) **0.1 t/d BSU operation for NEDOL process. Liquefaction behavior on various coals (2).** Tsukui, Yutaka (Mitsui Engineering and Shipbuilding Co., Ltd., Tokyo, Japan); Hashimoto, Takao; Matsuo, Kazuyoshi; Kanda, Nobuyasu; Yamaki, Toshio; Kato, Yoshinobu; Iwasaki, Toru; Saegusa, Hitoshi. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Within the technological development of bituminous coal liquefaction, being executed as a series of Sunshine project, by using a 0.1ton/d laboratory scale continuation unit, the eight previous kinds of coal in the NEDOL mode were added this time with five new kinds of coal in liquefaction experiment. In the Wandoan coal liquefaction experiment, the hydrogen consumption quantity, gas production ratio, etc. were equilibrated at about ten in number of solvent recycling rotations. However, the liquid side was late equilibrated and n-paraffin in recycling solvent became constant in concentration at about 25 in number of recycling rotations. Pacific coal, though higher than 40% in ash concentration, was extremely good in extraction. While Riverking coal was unstable, as compared with other coal, in extraction of distillation residue and low in concentration of n-paraffin in solvent. The higher coal is in sulfur and oxygen content, the larger its produced hydrogen sulfide, water and $CO+CO_2$ quantity is. The higher coal is in hydrogen content, the lower the hydrogen consumption quantity trends to be, under the identical condition. 1 ref., 5 figs., 2 tabs.

6614 (FSJ–8902, pp. 80-83) **Studies on the polymerization reaction of coal liquids (4). Behaviors of various coal liquid bottoms under heat treatment.** Aiura, Masato (Mitsubishi Chemical Industries, Ltd., Tokyo, Japan); Tazawa, Kazuharu; Kageyama, Yoichi; Kawai, Satoshi. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

The BCL process, which is a two-stage liquefaction method, is a bottom recycling method to have CLB (Coal Liquid Bottom), which is primary hydrogenation bottom, and HDAO (Hydrogenated Deashed Oil), which is reaction produced liquid of secondary hydrogenation system, recycle to the primary hydrogenation system. To prevent that process from the coking trouble, this report investigated brown coal liquid bottoms, obtained under different liquefaction conditions, in properties and behavior of weighing heavy when thermally treated. As a result of experiment, the velocity of weighing heavy and growth of anisotropical structure of pitch weighing heavy, by the thermal treatment of bottom, are related with the hydroxyl group quantity in bottom. The smaller the bottom is in hydroxyl group quantity, the more difficult the weighing heavy is, however the better the anisotropical structure is in growth. The hydroxyl group quantity in CLB obtained from the bottom recycling system is smaller than that from the solvent recycling system. Particularly the recycling of bottom residue (HDAO-B) in HDAO is effective on the prevention from coking. 4 refs., 5 figs.

6615 (FSJ–8902, pp. 84-87) **Influence of CLB species and temperature on de-ashing rate in solvent de-ashing.** Sumida, Shuichiro (Kobe Steel, Ltd., Tokyo, Japan); Okuma, Osamu; Nagae, Shin'ichi; Okuyama, Noriyuki; Saito, Kaizaburo; Matsumura, Tetsuo. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Ni-Mo/Al_2O_3 catalyst is used in brown coal two-stage liquefaction process (BCL process) which uses fixed bed reactor in secondary hydrogenation. In order to use this catalyst for a long term with stable condition, it is necessary to remove catalyst poisoning components in ashes which are contained in heavy liquid product (CLB) obtained in first hydrogenation. For a removing method of the poisonig components, solvent de-ashing process is adopted in BCL, in the process, CLB is dissolved in solvent and then the insolubles are separated by gravity. In this report, using the result of measurement

of the de-ashing rate through a batch de-ashing test plant, the degree of aggregation in precipitation of solids was estimated, and the effect of CLB species and de-ashing temperature on aggregation/precipitation was studied. As the result, in a toluene de-ashing of CLB, it was found that adequate de-ashing rate was obtained through aggregation of solids. Increasing temperature caused to make aggregation easy, further the degree of aggregation depended on CLB species, particle size distribution in de-ashing of Morwell coal CLB was smallest and the CLB was hard to aggregate. 1 ref., 6 figs., 2 tabs.

6616 (FSJ–8902, pp. 88-91) **Reaction mechanism of coal liquefaction using model compounds (3). Influence of reaction temperature and hydrogen pressure.** Ouchi, Koji (Hokkaido Univ., Faculty of Engineering, Sapporo, Japan); Ito, Hironori; Makabe, Masataka. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

In order to elucidate the reaction mechanism for hydrocarcking of Taiheiyo coal, the distribution of reaction products and the variation of solvent composition were examined with changing the reaction temperature and hydrogen pressure. Benzyl phenyl ether was used as the model compound. As the solvent, any of decalin, tetralin and naphthalene was used with a stabilized nickel catalyst. The conversion ratio was shown 14% at reaction temperature of 200^{0}C, it sharply increased to 98% with increasing temperature to 250^{0}C. At 250^{0}C, the greater part of products were converted to toluene (39%), methyl cyclohexane (5%) and cyclohexanol (42%); at 500^{0}C, the large portion of those were occupied by aromatics. It is important reaction mechanism in coal liquefaction that increasing temperature causes acceleration in cleavage of C-O bond, also acceleration in dehydration/gasification, and variation in components of the product. As the pressure is raised, saturation of aromatic ring and de-hydoxyle group reaction are increased markedly, and polymerization/condensation reactions are eliminated. 3 refs., 5 figs.

6617 (FSJ–8902, pp. 92-95) **Effects of iron-based catalysts on dehydrogenation of tetralin.** Kanda, Nobuyasu (Mitsui Engineering and Shipbuilding Co., Ltd., Tokyo, Japan); Hashimoto, Takao; Bacaud, Robert; Jamond, Marielle; Charcosset, Henri. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

In order to have basic knowledges on hydrogenation and re-hydrogenation behavior of solvents in coal hydrogenation liquefaction, the effects of iron-based catalysts on hydrogenation/dehydrogenation were studied using tetralin/naphthalene as a model. A gas flow type micro reactor with atmospheric pressure was used as an experimental apparatus. Tetralin, which was saturated with hydrogen gas at temperature of 60^{0}C, was fed to the reactor, Fe_2O_3 aerosol, which was prepared by H_2 - O_2 flame combustion of $FeCl_3$, was used as an iron-based catalyst precursor. As a result of the experiment, it was found that the dehydrogenation of tetralin was enhanced by Fe (PYRRHOTITE), but its activity was not so high as Mo. However, when Fe was mixed with activated carbon or carbon black or alumina, the activity was improved. Iron-based activated carbon catalyst showed higher activity than Mo catalyst even with a small quantity. 6 refs., 3 figs., 2 tabs.

6618 (FSJ–8902, pp. 96-99) **Studies of coal liquefaction (60). Catalysis of sulfided Fe and Mo on the hydrogenation of aromatics.** Fukasawa, Toshiharu (The Univ. of Tokyo, Faculty of Engineering, Tokyo, Japan); Ogata, Eisuke; Kamiya, Yoshio. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Conversion and selectivity on the hydrogenation of 2 to 4 rings aromatic compounds and naphthalene-base compounds with one or two methyl radicals by use of sulfided Fe and Mo catalyst were examined. The substrate, solvent (decalin or biphenyl), catalyst and sulfur were put in an autoclave (electromagnetic rotary stirring type) with hydrogen, the reaction was taken place at 350^{0}C for one hour. The hydrogenation of 2 to 4 rings aromatic compounds without having substitutional radical was carried out with the catalyst. As a result, it was found that the conversion of anthracene was most high. As for the relative activity of Ni-Mo-S base catalyst versus Fe-S base catalyst, it was about twenty times as large as conversion of Fe-S base in naphthalene, which has low hydrogenation reactivity. And, it was about three times in fluoranthene, which has comparatively large reactivity. The hydrogenation reactivities of methylnaphthalenes excepting 1-methylnaphthalene, were enhanced by Fe-S base catalyst, and they were restrained by Ni-Mo-S base catalyst. 1 ref., 8 tabs.

6619 (FSJ–8902, pp. 100-103) **Studies on coal liquefaction (61). Hydrocracking of 1,1'-dinaphthylmethane and coal liquefaction.** Wei, Xian-Yong (The Univ. of Tokyo, Faculty of Engineering, Tokyo, Japan); Ogata, Eisuke; Futamura, Shigeru; Kamiya, Yoshio. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

The effects of catalyses of FeS_2 and Ni-Mo-S catalysts and of solvent on the hydrocracking of 1,1'-dinaphthylmethane (DNM) at low temperature, and relevance to coal liquefaction, were studied. Much naphthalene and 1-methylnaphthalene were produced by the hydrocracking of DNM using Ni-Mo catalyst at high temperature of 400^{0}C or above, as well as that in the case of iron catalyst. The variation with time of product selectivities using pyrite (FeS_2) catalyst at temperature of 300^{0}C was basically similar with the reactions at high temperature, the production amount of hydrogenated DNM was little. By use of Ni-Mo-S catalyst at 300^{0}C, a lot of hydrogenated products of DNM were produced, the reactions differed from those by use of iron catalyst. Liquefaction with FeS_2 catalyst was gradually enhanced with the increase of catalyst addition, on the other hand, liquefaction with Ni-Mo-S catalyst was markedly enhanced even with a small quantity of catalyst addition. 2 refs., 3 figs., 5 tabs.

6620 (FSJ–8902, pp. 104-107) **Studies on the catalysts for coal liquefaction (6). Specific behaviours of various catalysts in the hydrogenolysis of model compounds (Effect of temperature and hydrogen pressure).** Ikenaga, Naoki (Kansai Univ., Faculty of Engineering, Osaka, Japan); Oda, Hirokazu; Yokokawa, Chikao. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Several kinds(10 kinds) of catalyst and model substances (11 kinds) were used for hydrogenolysis to investigate components of products and conversion rates, in order to clarify effects of all catalysts used in high pressure hydrogenolysis of liquefied coal. Reactions were performed in an autoclave of 50ml capacity at conditions of 10MPa initial hydrogen pressure, and 693K reacting temperature for 30 minutes, and a gaschromatography and GC-MC were used to analyze. When these results were compared with the test results previously reported at moderate conditions(initial hydrogen pressure of 5MPa, temperature of 653K for 1 hour), the conversion rate increased with the rise of temperature, but some catalysts indicated changed reacting directivity. That is, dihydro-compounds decreased and tetrahydro- and octahydro-compounds incresed in a condensed aromatics. Fe_2O_3+S of used catalysts apts to suppress the seission of aromatic methylene bond. 4 refs., 1 tab.

6621 (FSJ–8902, pp. 108-111) **Studies on the catalysts for coal liquefaction (7). Specific behaviours of various catalysts in the hydrogenolysis of a solvent-refined lignite.** Ikenaga, Naoki (Kansai Univ., Faculty of Engineering, Osaka, Japan); Fukumi, Junko; Oda, Hirokazu; Yokokawa, Chikao. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Catalytic activity was studied at comparatively severer conditions to investigate features of several kinds of catalyst for coal liquefaction. SRL(solvent refined lignite) was used as the sample; Adekins catalyst, Fe_2O_3+S, MoO_3-TiO_2, and MoS_3-Al_2O_3 were used as catalysts; and tetralin and creasote oil were used as solvent. After the reaction in an autoclave at conditions of 10MPa initial hydrogen

pressure, 693K temperature and 6 hours, reaction was again performed for 6 hours by introducing hydrogen up to 10MPa. After separating solvents by vacuum distillation, products were analyzed by NMR for solvent fractioned solubles. Reactive directivity of each catalyst agreed nearly with the previous results carried out by using model substances. Activity of Adekins catalyst for bridge scission was weakened remarkably by existing tetralin but MoO_3-TiO_2 was hardly affected by solvent. 4 refs., 2 tabs.

6622 (FSJ-8902, pp. 112-115) **Coal liquefaction by a super acid.** Kotanigawa, Takeshi (Government Industrial Development Lab., Sapporo, Japan); Yokoyama, Shin'ichi; Yamamoto, Mitsuyoshi; Maekawa, Yosuke. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Sulfate radical prepared through sulfide is thought to act as super acid other than the catalytic action of sulfide in the iron oxide-sulfur catalyst used for coal liquefaction. Therefore, comparative study was performed by using another super acid ZrO_2/$Al_2O_3(SO_4)^{2-}$(ZA). Catalysts used for this experiment were super acid catalyst(ZA) prepared by $ZrOCl_2$ and $Al(NO_3)_3$, FeS_2 and ammonium sulfate (AS). Experiments were carried out with and without catalysts, with and without solvent(tetralin), and under hydrogen or nitrogen atmosphere and remarkable features were found depending on these combinations. The coexisting effect of tetralin and AS could not be found but other coexisting effect was remarkable. Further, it was verified that coexisting of FeS_2 with solvent decreased the activity which was caused by the adsorbing difference to the solvent. 4 refs., 2 figs., 2 tabs.

6623 (FSJ-8902, pp. 116-119) **Low temperature hydroliquefaction of Morwell brown Coal in the H_2-Ni-phenoiic solvent system.** Takemura, Yasuhiro (Akita Univ., Akita, Japan); Saito, Yoshihito; Okada, Kiyofumi; Koinuma, Yutaka. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Phenolic compounds are known as strong coal liquefaction solvents. Therefore, dissolving powers for coal of various phenolic compounds were measured to study the action and the possibility of low temperature liquefaction at 300^{0}C or less by using together Ni catalyst. Reactions were carried out in an autoclave by adding 20 kinds of solvent and Ni catalyst(or without Ni catalyst) to 2g Morwell coal, at conditions of 10MPa Ar or hydrogen atmosphere, 250-270^{0}C and 1 hour. In case of phenol and cresole solvents, followings were found: solvent intermediates hydrogen transfer from H_2 even without catalyst; the tendency increases with Ni catalyst; phenolic OH has coal liquefying function; and hydrogenated aromatic ring has lower liquefying function. It was found that conversion rate(gas yield and benzene soluble yield) became 70% or more and low temperature hydroliquefaction was possible. 7 refs., 4 tabs.

6624 (FSJ-8902, pp. 120-123) **Catalytic activity of iron sulfate and sulfide for Akabira coal liquefaction.** Yokoyama, Shin'ichi (Government Industrial Development Lab., Sapporo, Japan); Yamamoto, Mitsuyoshi; Maekawa, Yosuke; Kotanigawa, Takeshi. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

It was found that sulfate had the catalytic activity as a super acid in the previous liquefaction of Taiheiyo coal, and the experiment was carried out to Akabira coal of different coal rank. The catalyst was $Fe_2O_3(SO_4)^{2-}$(K) which was prepared by the coprecipitation from aqueous solution of ferric sulfate and urea and contains 1.1% sulfate. Other catalysts used in this experiment were FeS_2 and ammonium sulfate(AS). AS had lower hydrogenolyzing activity and conversion rate but dehydrogenating activity was larger, so that it cleaved the aromatic condensed rings of Akabira coal to decrease the ring number, resulting low number rings. Further, a large amount of hydrogen was consumed to stabilize fragments occurred by dehydrogenation through hydrogenation. FeS_2 and K catalysts had large hydrogenolyzing activity and condensed rings of Akabira coal were hydrogenolyzed to produce compounds having aliphatic side chains and to reduce aromaticity. 3 refs., 4 tabs.

6625 (FSJ-8902, pp. 124-127) **Studies on the hydrocracking of deashed oil (6). Study of NBCL secondary hydrogenation catalyst by EXAFS method.** Kaneko, Takao (Mitsubishi Chemical Industries Ltd., Tokyo, Japan); Ushikubo, Takashi; Akai, Toshio; Koike, Yasuo; Kageyama, Yoichi; Kimura, Takao; Kawai, Satoshi. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Two step hydrogenation technique is being developed for an Australian brown coal and fresh and several times used catalysts that included Ca-Ni-Mo/Al_2O_3(C), Ni-Mo/Al_2O_3(N) were studied for the change of Mo sulfurized and dispersed conditions by using EXAFS method. Followings were clarified from radical distribution around Mo obtained from Fourier transformation of EXAFS and further by comparing Mo-O distance and coordination number: C catalyst has larger rate of MoS_2 structure than that of N catalyst; Fresh C catalyst has $CaMoO_4$ structur and changes to MoS_2 by sulfurizing; Mo cohesion proceeds in catalyst used for long time in a pilot plant and the degree is larger in upper part of the catalytic layer. 8 refs., 3 figs., 1 tab.

6626 (FSJ-8902, pp. 128-131) **Poisoning effect of metal deposits on the catalytic activities of molybdate catalysts.** Yoshimura, Yuji (National Chemical Lab. for Industry, Tsukuba, Japan); Sato, Toshio; Shimada, Hiromichi; Matsubayashi, Nobuyuki; Nishijima, Akio; Endo, Shigemi; Yoshitomi, Suehiko. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Deactivation of catalysts can be classfied to that by reaction products and to that by the deterioration of catalyst itself. This report studied the effect of metals contained in coal liquefied oil and metals contained in vacuum distillated gas oil from petroleum on basic activities of Ni-Mo and Co-Mo catalysts to clarify problems relating to the later. The experiment was carried out by comparing metal decorated catalysts prepared by impregnated trially manufactured catalysts in solutions of each metallic salt with spent catalysts which had been used for hydrogenation and desulfurization of vacuum distillated residue. Catalytic activities were determined by hydrogenation rate and hydrocracking rate in batch reactions for diphenylmethane. It was found that alkali and alkali-earth metals apt easily to poison active points for hydrogenation and that Fe and V poison remarkably active points for hydrogenation but generate new active points. Practical deteriorating mechanism of activities can be explained to some degree from comparison of deposited metals on spent catalysts. 5 refs., 4 figs., 2 tabs.

6627 (FSJ-8902, pp. 132-135) **Catalyst design for upgrading coal-derived middle distillates.** Shimada, Hiromichi (National Chemical lab. for Industry, Tsukuba, Japan); Sato, Toshio; Yoshimura, Yuji; Matsubayashi, Nobuyuki; Nishijima, Akio; Yoshitomi, Suehiko. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

It is known that two stage process of hydrogenation and hydrocracking is necessary for upgrading to get fuels substituting petroleum from coal liquefied oil. This report investigated the suitability of zeolite supported catalyst as the later hydrocracking catalyst. Liquefied oil(201-308^{0}C boiling point) from Wandoan coal was used as raw material and alumina supported on zeolite and impregnated by NiO-MoO_3 was used as the catalyst. From the experimental results, higher the reacting temperature in the first process, higher the gasolin yield, and higher the hydrogenation degree, easier the progress of second reaction but easier the poisoning of catalysts by nitrogen containing compounds. From the investigation of reacting mechanism by using tetralin as the model compound, it was found that the function decomposing naphthene rings to get gasolin at high yield and countermeasures to prevent coke pollution are required. 2 refs., 5 figs.

6628 (FSJ-8902, pp. 136-139) **Hydrocracking of preasphaltene.** Miki, Yasuo (National Chemical Lab. for Industry, Tsukuba, Japan); Yamadaya, Shoko; Oba, Masaaki; Sugimoto, Yoshikazu. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese).

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Hydrocracking technique of preasphaltene(PA) and asphaltene(As) in coal liquefied oil was studied to investigate features and reactive behavior of heavy components. Coal liquefaction was carried out in an autoclave at conditions of 80kg/cm^2, 450^{0}C and existence of iron oxide/sulfur; and hydrocracking of heavy conponents was carried out at 440^{0}C, for 72 hours, and by using Ni-Mo/Al_2O_3 and several solvents. When PA and As made from a same coal were compared, PA contains higher oxygen and hydrogen and shows lower H/C ratio but this tendency was different in different coals. PA ans As in prepared oil were hardly found by hydrocracking of PA and As but HS distillate remained and it was thought difficult to crack up to distillated oil. Further, the solvent incorporation into heavy components was hardly found, by estimating from the material balance before and after the reaction. 1 fig., 3 tabs.

6629 (FSJ–8902, pp. 140-143) **Hydrocracking of coal-derived distillate.** Sugimoto, Yoshikazu (National Chemical Lab. for Industry, Tsukuba, Japan); Miki, Yasuo; Niwa, Yoshio; Oba, Masaaki; Yamadaya, Shoko. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

The detailed analysis on reaction concerning hydrogenation of distillated components in primary coal liquefied oil is hardly performed. Therefore, hydrocracking of model compounds and dislillate were analyzed to study their reactive behaviors. Several kinds of aromatic and straight chain compounds were used as the model compounds. The reaction was carried out by using Ni-Mo/$A1_20_3$ catalyat and at conditions of 8MPa and 1 hour reaction. From the experiment at 375^{0}C or less on the model compounds, following results could be estimated for each type compounds: Straight chain paraffins did not react, aromatic compounds were hydrogenated (but hydrogenation of benzene ring is difficult to occur), phenol compunds were dehydroxylated, and nitrogen compounds were dehydrodenitrified, The increase of reacting temperature for distillated components increased light components and 92% of polar compound decomposed at 400^{0}C. 1 ref., 1 fig., 2 tabs.

6630 (FSJ–8902, pp. 144-148) **Effect of prehydrotreating on the catalytic cracking of coal liquid.** Sato, Yoshiki (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Yamamoto, Yoshitaka; Kamo, Toru; Inaba, Atsushi; Miki, Keiji. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

When catalytic cracking being used to manufacture gasoline, kerosene and gas oil from petroleum heavy oil, is applied to coal derived oil, the pretreating such as denitrification is said important. Therefore, the catalytic cracking was carried out to hydrogenated oil at various conditions by using Ni-Mo/$A1_20_3$ catalystto study the effect of hydrocracking degree. Hydrogenation was performed in a small flowing system at conditions of 350-390^{0}C reacting temperature, and 50-150kgf/cm^{2}G hydrogen pressure. Hydrocracking was carried out at 482^{0}C and ordinary pressure in a fluidized catalytic condition. Higher the hydrogenating degree as the result of catalytic cracking, higher the gas generation and lower the coke generation. The ratio of heavy distillate decreased with the rise of pretreating temperature and the conversion ratio became from 23wt% to 40wt% when the pretreating temperature was raised from 350^{0}C to 390^{0}C, indicating the large change. 2 figs., 2 tabs.

6631 (FSJ–8902, pp. 148-151) **Study for material and thermal balance of coal gasification.** Kaiho, Mamoru (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Makino, Mitsunori; Kobayashi, Mitsuo; Yamada, Osamu; Yamashita, Yasumasa; Fujinami, Shosaku. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

When coal is gasified with steam and oxygen, analyzing method of material and thermal balace according to overall reaction formula was studied. Gas amount generated($CO+H_2$) is equal to the difference between conversion rate from coal to gas and oxygen ratio(supplied oxygen amount/theoretical oxygen amount for combustion) multiplied by 2 power of theoretical oxygen amount for combustion. Conventional gasification requires the minimization of (CO_2+H_2O), so that steam supplying amount for oxygen ratio was calculated to achieve this requiement. Further, these relations were shown in graphs. Moreover, cold gas efficiency E is equal to the difference between coal to gas convertion ratio and oxygen ratio multiplied by constant K. K is the value related to elementary analyzed values and combustion heat for coal and equal to about 1.33. The heat loss equation (1-E) at gasification was derived and the relation to oxygen ratio was shown on a graph. A large part of heat loss is caused by the sensible heat of generated gas and the loss from furnace wall. Higher the gasification temperature, larger the heat loss and oxygen ratio. 6 figs., 1 tab.

6632 (FSJ–8902, pp. 152-154) **Steam gasification of high sulfur coals with calcium hydroxide.** Otsuka, Yasuo (Tohoku Univ., Sendai, Japan); Asami, Kenji. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

$Ca(OH)_2$ is known as the steam gasification catalyst for brown coal. This report studied to widely verify the effectiveness for steam coal containing much sulfur. As samples, 9 kinds of coal from brown coal to bituminus coal were used and their sulfur contents were 1.3-3.7% except 0.3% for Yallourn coal used as the standard. From the char conversion obtained after Ca carrier prepared by blending 5% $Ca(OH)_2$ to these coals in water respectively was held in steam(66kPa) at 600-700^{0}C for 2 hours, it was confirmed that the carrier had high catalytic activity for any high sulfur coal. Although the gasification degree was smaller for coals of high sulfur and high degree of coalification, similar catalytic activity to Yallourn coal of low sulfur could be verified. It was also verified that equivalent conversion could be obtained at smaller temperature by 100-150^{0}C than conventional one by adding the catalyst. 4 refs., 1 fig., 1 tab.

6633 (FSJ–8902, pp. 155-158) **Measurement and correlation of the gasification rates of the chars produced by flash pyrolysis.** Miura, Koichi (Kyoto Univ., Faculty of Engineering, Kyoto, Japan); Silveston, P.L. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Coal flash pyrolysis is paid attention as a manufacturing method for benzene and toluene, etc. but the problem is the large amount of chars produced at the same time, so that the gasification rates of chars were investigated. For this experiment, 18 kinds of char produced by flash pyrolysis and rapid hydrocracking of Canadian coals were used as samples. Samples were gasified after raising to previously determined temperature of 550-650^{0}C at the rates of 2, 5 and 10K/min. The relation between reaction rate of chars, temperature and reaction time agreed well with the rate equation by Bhatia et al and frequency factors, activation energies and structural parameters could be determined. The values of E were 120-140kj/mol in many cases, and parameters indicated the features in case of some manufacturing conditions. Severer the manufacturing condition, and larger the demineralization degree, smaller the reactivity. 6 refs., 10 figs., 5 tabs.

6634 (FSJ–8902, pp. 159-162) **On the reactivities of various coal chars with CO_2 and O_2 by using pulsed gasification technique.** Suzuki, Toshimitsu (Kyoto Univ., Faculty of Engineering, Kyoto, Japan); Sakasita, Yoichi; Watanabe, Yoshihisa. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

The pulsed technique which is known as an analytic method for a nonstationary reaction on solid surface, was applied to the catalytic gasification of coal to study the correlation between various informations as the response and char gasification rate. CO_2 pulsed gasification was carried out at 750^{0}C and 800^{0}C by using chars obtained by raising temperature to 800^{0}C for 16 kinds of coal. CO generating peaks, that is, main peak and satellite peak which were obtained as the response of the pulsed gasification at 800^{0}C

indicated respective characteristic patterns for brown coal, subbituminus coal and bituminus coal. It was found that the satellite peak was caused by contained iron oxide and the dispersion had some influence. The superior correlation between CO amount generated by the pulsed gasification and the gasification rate measured under a constant flow, was found. It was verified that the pulsed gasification technique is useful to evaluate reactivities of chars by trially making O_2 pulsed gasification. 6 refs., 4 figs., 1 tab.

6635 (FSJ–8902, pp. 163-166) **Effect of residue char on ash fusion.** Ninomiya, Yoshihiko (Tokyo Univ. of Agriculture and Tech., Faculty of Tech., Tokyo, Japan); Hironaka, Masahiro; Miyauchi, Tsunekazu; Ishibashi, Takeshi; Hirato, Mitsuho. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

As coal ash in the fluidized bed coal gasification furnace is extracted out of the system, the influence of carbon on the fusion of ash to be used was studied, also together with the occurrence of bubbling phenomenon upon being added with carbon. In the experimentation, three kinds of coal, ie., Pacific coal, Datong coal and Blair Athol coal were used. As a result, if carbon existed in coal ash, mineral matter (mainly iron) in ash was reduced by carbon with the furtherance of ash in fusion. The fusion temperature, if carbon existed, was acknowledged to lower by 15 to 50^{0}C. Also, a bubbling phenomenon by the oxidation of carbon being observed, ash pellet expanded to be doubled to trebled. That phenomenon was hardly acknowledged, if not added with carbon, and known to be characteristic, only if added with carbon. 1 ref., 5 figs., 3 tabs.

6636 (FSJ–8902, pp. 167-170) **Characterization and pyrolysis gas analysis of solvent extract from coal liquefaction residues.** Furuta, Takeshi (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Maruyama, Katsuhisa; Yamaguchi, Kiyoshi; Shiraishi, Minoru; Imuta, Kazutoshi. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Liquefaction residue contains not only much inorganic matter (30 to 40% as ash content), concentrated of inorganic matter in coal and catalyst added therewith, but also a considerable quantity of mainly oil content and other soluble organic matter. In order to design to effectively utilize that liquefaction residue, in this experimentation, liquefaction residue fractionated from solvent was obtained in mean chemical property values, while upon thermally analyzing fractionated matter and analyzing produced gas, liquefaction residue was elucidated in characteristics. Liquefaction residue sample used in the experimentation was Illinois No.6 and Wandoan coal in raw material. As an experimentation result, liquefaction residue being low in oxygen content as compared with raw coal, Illinois No.6 and Wandoan coal decreased to less than 1/5 and 1/3, respectively, in liquefaction residue. While they slightly increased in nitrogen. Also the change in production velocity of different gas, by the thermal treatment of solvent-separated matter, was elucidated. 2 figs., 4 tabs.

6637 (FSJ–8902, pp. 171-174) **Flash pyrolysis of coal treated by several solvents.** Miura, Koichi (Kyoto Univ., Faculty of Engineering, Kyoto, Japan); Mae, Kazuhiro; Asaoka, Seiji; Hashimoto, Kenji. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

By developing a method to design to improve liquid matter, produced by the flash pyrolysis of coal, pretreated by the swelling with solvent, and elucidating the pretreatment and flash pyrolysis conditions, and influence of solvent species to be given to the liquid product yield, the hydrogen conversion during the pyrolysis was studied. As a result, the pretreatment condition by the swelling with solvent was optimized to be at 250^{0}C by 1MPa. As for the tetralin-swelled coal in flash pyrolysis, the tar yield largely enlarged to about 32wt%daf, about 1.5 times as large as raw coal, in the vicinity of 760^{0}C in pyrolysis temperature, with the sufficient acknowledgement of tetralin-swelled effect. Moreover, it was confirmed that the swelling treatment, using hydrogen donative solvent, can largely enlarge the tar yield and that its hydrogen donative effect, independent of solvent species and pyrolysis temperature, can be well indicated by the hydrogen transfer quantity (H_r) from solvent to coal. 1 ref., 6 figs., 2 tabs.

6638 (FSJ–8902, pp. 175-178) **Study on the thermal behavior of coal under high temperature and high pressure by using semi-micro reactor and extractor.** Aida, Tetsuo (Kinki Univ., Faculty of Engineering, Osaka, Japan); Slomka, B.; Squires, T.G. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

To eliminate, as mush as possible, the influence of soluble content (bitumen), contained in coal from the biginning, and primary decomposition soluble content, bridged high molecular (unsoluble) content was studied in thermal behavior, by manufacturing a semi-micro scale (30 to 500mg) Flow Mode reactor/extractor, equipped with a UV-detector and temperature programing unit. That reactor/extractor is advantageous, as solvent continuously passes through sample coal bed under a high temperature, in being able to quickly remove the solved content (bitumen and primary decomposition soluble content) out of the reaction system and, also, continuously monitor, by a UV-detector, the dependentness on time and temperature of decomposition product. Moreover, it is characterized with being able to arbitrarily fill the sample bed with solvent, added with the specified reagent. 1 ref., 6 figs.

6639 (FSJ–8902, pp. 179-182) **Rapid pyrolysis of coals in down-flow reactor.** Hirosawa, Kunio (Government Industrial Development Lab., Hokkaido, Sapporo, Japan); Morita, Mikio. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

The rapid pyrolysis of coal, by the free fall method as a pyrolysis method, able to recover high calorie gas and tar, and materializable in energy saving, was studied. As a result, by letting heated space fall down with heating medinum during 2 to 5 seconds and compensating it with heat quantity as specified, coal could be achieved in effective pyrolysis. Also, caking coal, if properly added with non-caking coal, came to be expected in possible continuous pyrolysis. Next, the char yield diminished with the heightening in pyrolysis temperature and asymptotically approached about 50%. Produced char is high also in heating value and has no particular problem in combustibleness. Moreover, the gas yield enlarged with the heightening in pyrolysis temperature. Produced gas is abundant in hydrogen and methane, and high in calorie value, as also containing C_2-C_4 hydrocarbon gas. While the tar yield attained its maximum value, about 30%, at 600 to 650^{0}C. The heightening in temperature of tar decreased the aliphaticity and abundantly increased the aromaticity. 1 ref., 4 figs., 4 tabs.

6640 (FSJ–8902, pp. 183-186) **Rapid hydropyrolysis of coals in a free-fall type pyrolyzer.** Sugawara, Takuo (Akita Univ., Mining College, Akita, Japan); Sugawara, Katsuyasu; Nakatani, Shinya; Nishiyama, Yoshinori. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

As a series of research on the pretreatment of coal, by the particulate free fall type pyrolyzer, able to pursue the rapid pyrolysis of coal in dynamical behavior, a rapid hydropyrolysis was made with, as sample, one kind of caking coal and three kinds of non-caking coal. As a result, volatile matter, after about 90cm in length of heating section, attained, in yield, to an almost constant value, which was 1.3 times as high as that of industrial volatile matter. While the internal surface area was maximized at 60 to 90cm in length of heating section. In the change in form-distinguished sulfur distribution, organic sulfur content quickly lowered not so far as 90cm in length of heating section. Moreover, the result of desulfurization in the rapid hydropyrolysis, if compared with that of ordinary pressure and pressurized hydrogen treatments, with a low velocity and heightening in temperature, was known to be high in emission velocity of organic sulfur into gaseous phase and low in change velocity to heat-resisting organic sulfur. 6 refs., 5 figs., 2 tabs.

6641 (FSJ–8902, pp. 187-190) **Fast pyrolysis of some western Canadian subbituminous coals.** Takeuchi, Masami (The Kansai Coke and Chemicals Co., Ltd., Hyogo, Japan); Berkowitz, N. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

It is expected to develop the technology on effective use of brown coals having enormous reserves in Western Canada. For this purpose, continuous coal supplying air conveyor type spider reactor was manufactured in order to realize quick heating pressurized fast pyrolysis, and experiments by four-kind Western Canadian coals were conducted. In the experiments, the state of changes in recovery rate of their products, gas composition due to pressure, temperature, atmosphere gas was observed. As the results, it was confirmed that tar recovery rate of the coals was low, liquefied material was obtained in high efficiency. These were seemed to be caused not by the difference between experimental methods, but by difference between the discrepancy which tar recovery rate of Western Canadian coals used in the experiment disagrees with the relation between rank of coalification and tar recovery rate which has been reported till now. About the coals having same rank in coalification, their reactivity, product recovery rate, composition were not fixed, and it was understood that they were unable to estimate by the experimental data currently in use. 5 refs., 5 figs., 2 tabs.

6642 (FSJ–8902, pp. 191-194) **Hydrocracking of volatile matter from coal pyrolysis.** Xu, Wei-Chun (Tohoku Univ., Sendai, Japan); Tomita, Akira. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

In the catalytic hydrotreating of primary volatile matter from coal pyrolysis, a possibility on increase of the yield of liquid hydrocarbons was studied. An experiment was carried out using Australian Liddell coal through a quartz glass two-stage reactor. As a result of the experiment, it seems that the hydrocracking is carried out successively. Consequently, it was found that primary cracking products can be converted to expectant secondary products to a certain extent by optimization of the operational factors such as secondary reaction temperature, cracking and hydrogenation activities of a catalyst, and residence time within catalyst layer. For instance, almost all hydrocarbons were able to be converted to methane through holding sufficient residence time within catalyst layer, further, the yield of BTX could be increased markedly through moderate hydrocracking. 2 refs., 3 figs., 1 tab.

6643 (FSJ–8902, pp. 195-198) **Activation of coal with carbon dioxide and its utilization for heavy oil upgrading.** Fujimoto, Kaoru (The Univ. of Tokyo, Faculty of Engineering, Tokyo, Japan); Nakamura, Ikuyo; Fujimura, Takashi. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

A catalyst was prepared as follows: activation of brown caol was carried out using carbon dioxide or steam at high temperature and then iron was added to the activated coal carrier. An experiment, in which the prepared catalyst is used, was conducted on heavy oil cracking under the conditions of thermal cracking with pressurized hydrogen. As the result, through the high temperature carbon dioxide treatment of brown coal, it was made possible to reform the surface of coal to the conditions which was suitable for adsorption of the coke precursor and hydrogen transfer on the carrier. And the catalyst, of which iron was added to the carrier, showed superior activity in hydrogen transfer type thermal cracking. Wandoan and Morwell coals gave excellent carbon carrier which asphalten was cracked heavily, as well as the production of lighter cracked-tar. As for brown coal system carrier which produced through carbon dioxide treatment, dehydrogenation activity for methylcyclohexan, adsorption property, and bulk density correlate closely with the result of heavy oil craking, and it is made possible to evaluate the catalyst through measuring these characteristics. 3 refs., 1 fig., 1 tab.

6644 (FSJ–8902, pp. 199-202) **Oxidation reforming of coal liquefaction residues.** Kawashima, Hiroyuki (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Yamashita, Yasumasa; Kaiho, Mamoru; Kobayashi, Mitsuo; Makino, Mitsunori; Yamada, Osamu. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

The development of effective gasification technique for coal liquefaction residues which amount to 30-35% of coke making coal, is desired. This report studied change of properties such as softening point and adhesion force by oxidation reforming of coal liquefaction residues. Two liquefaction residues made from Illinois No.6 and Yallourn coal were used as the samples. At oxidation temperatures of 150^{0}C and 290^{0}C, the oxidizing rate of Yallourn coal residue(Y) was larger and the increasing rate of softening point for Illinois residue(I) was larger. Particle adhesion force of I was 5dyn and that of Y was 3.2dyn, because the later indicating lower value contained much total oxygen. Higher the oxidation degree, lower the adhesion force for two samples, and the adhesion force became equivalent to that of the coke making coal at 5% oxidation. The decrease of adhesion force by oxidation is caused by the fact that the functional group containg oxygen weakens the interparticle force. 3 refs., 4 figs., 2 tabs.

6645 (FSJ–8902, pp. 203-206) **Effect of oxidation on caking properties and extraction yield of coal.** Seki, Hiroyuki (Tohoku Univ., Sendai, Japan); Ito, Osamu; Iino, Masashi. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

This report studied the change of caking properties, relation between extraction yield and caking property, and structural change when raw coal, mixed solvent extract and residual coal were separately oxidized. Lower Kittanning coal which was ground to 100 mesh or less was used as the sample. Solvent extraction was performed by using 250ml of a mixed solvent of carbon disulfide and N-methyl-2-pyrrolidine to 10kg coal at conditions of room temperature, and ultrasonic energy application for 45 minutes. The fluidity decreased by oxidation of raw coal but the correlation between oxidation time and extraction yield could not be confirmed up to 22 hours after oxidation started. The swelling did not change for the constant period of oxidation and decreased suddenly after that period. The oxidation of residual coal(polymer phase) occurred easily and affected the fluidity. Further it was suggested that the softening of low molecular components existing originally in raw coal contributed large to coal softening. 8 refs., 5 tabs., 2 tabs.

6646 (FSJ–8902, pp. 207-210) **Coal oxidation with oxygen at low temperature coal oxidation in gas phase and in alkali aqueous solution.** Yoshida, Yasukazu (The Univ. of Tokyo, Faculty of Engineering, Tokyo, Japan); Ogata, Eisuke; Kamiya, Yoshio. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

In this study, experiments on coal oxidation in oxygen stream under atmospheric pressure, coal oxidation in alkali aqueous solution, solubilization of gas phase oxidized coal into alkali aqueous solution, and oxidation of coal after super critical extraction by toluene, were conducted at relatively low temperature (about 130^{0}C). As the results, the followings were clarified. The oxygen consumption in the beginning of coal oxidation becomes large with increasing carbon content of the coal. The large portion of organic matter in coal is solubilized to alkali aqueous solution at 150^{0}C or above through oxidation in a suspension of coal and alkali solution. The structure of raw coal is reflected in that of humic acid. Super critical extraction by toluene does not give a good effect on coal oxidation. Different behavior is found between coal oxidation in gas phase and in alkali aqueous solution. 11 tabs.

6647 (FSJ–8902, pp. 211-214) **Coal cleaning for liquefaction (8). Removal of the harmful components for liquefaction by treatment with CO_2 and H_2O.** Otaka, Yasuo (Sumitomo Coal Mining Co., Ltd., Tokyo, Japan); Hirai, Akihiko; Onishi, Takao; Matsuo, Kiyotaka. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference*

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In order to remove Ca nad Mg which cause carbonate deposits and Cl which causes corrosion in a coal liquefaction reactor, an experiment on the application of CO_2, which is obtainable relatively easily in a liquefaction plant, has been conducted. As the results, the followings were found: Simultaneous removal of Ca, Mg and Cl, which are harmful components for liquefaction, were made possible by treatment with CO_2 and H_2O. In low coal rank coals with low removal rate of the harmful components, the removal rate could be improved through improvements of the treating conditions such as treating time, pH value of the solution and others. It was clarified that this treatment was an effective method as a pretreatment for liquefaction due to the following facts: the treatment under the conditions of room temperature and atmospheric pressure can be done, the effects of the treatment on organic materials in coal are little, and flue gases in the liquefaction plant can be utilized in the treatment. 7 refs., 6 figs., 1 tab.

6648 (FSJ–8902, pp. 215-217) **Coal cleaning for liquefaction (9). Removability of harmful components for liquefaction in pre-heated coal.** Akiyama, Masaru (Sumitomo Coal Mining Co., Ltd., Tokyo, Japan); Otaka, Yasuo; Matsuo, Kiyotaka. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Carbon dioxide processing is effective to remove harmful components such as Ca and Mg which cause carbonate deposition in a coal liquefaction reactor and Cl which causes the corrosion of a distilling column. For these reasons, the effect of preheating in CO_2 processing was verified in experiments. CO_2 processing was carried out at room temperature and determined agitating rate for 1 hour by injecting the constant rate of CO_2 into water-10% coal slurry. The preheating at 300°C or less resulted that higher heating value increased, and H/C ratio, carboxyl content, moisture wt% and critical wetting surface tension decreased along with the increase of preheating temperature. When CO_2 processing of preheated coal was compared with that for raw coal, Ca removing rate of preheated coal at 250°C was equal to or more than that for raw coal. 6 refs., 3 figs., 1 tab.

6649 (FSJ–8902, pp. 218-221) **Chemical desulfurization and deash of coal using a microwave and caustic alkali treatment.** Ogawa, Katsumi (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Kamegaya, Hiroshi; Hasuda, Tetsuhiko. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

The microwave processing which enables shorter, room temperature and atmosperic processing owing to heating not only from the surface but also from the inner part of coal sample, was applied to coal desulfurization and deashing. Cleaned raw coal of Yotuyama Honso of Miike coal, Taiheiyo coal and Ayrshire coal containing much inorganic sulfur from US Indiana were used as samples. Desulfurization could not be confirmed but ash content decreased with the increase of radiation time for Taiheiyo coal. Ash content increased by radiation for 2 minutes for Ayrshire coal like Yotuyama coal. Hydrogen and sulfur decreased but nitrogen did not decrease with the increase of the radiation for Yotuyama coal. Excess microwave energy will decompose coal and increase of heating value loss. 6 figs., 2 tabs.

6650 (FSJ–8902, pp. 222-225) **Hydrocracking of SRC over supported molybdenum catalysts.** Hanaoka, Koji (Osaka Univ., Faculty of Engineering, Osaka, Japan); Song, Chunshan; Nomura, Masakatsu. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Two kinds of SRC(solvent refined coal), which are from Wandoan subbituminous coal and from Akabira bituminous coal, were obtained at the process development unit(PDU), 3t/d, and their catalytic hydrogenolysis reaction was analyzed with nickel sulfide-molybdenum catalysts prepared by four kinds of alumina supports(60-750A) with different pore size. Gas phase and tetralin were used to supply hydrogen. As a result, pre-asphaltene(BI) decreased and the conversion ratio of SRC grew when the pore size increased. In regard to hydrogen consumption, with the increase in the pore size, gas phase hydrogen increased a little while hydrogen consumption from tetralin greatly decreased. Consequently, it was found that catalysts with a big pore size were more effective for improving hydrocracking of SRC containing a lot of BI and asphaltene and for controlling its reserve reaction. Moreover, it was understood that such catalysts had a desirable effect that they could reduce the dependency to hydrogen donating solvent. 6 refs., 2 figs., 2 tabs.

6651 (FSJ–8902, pp. 226-229) **Hydrocracking of asphaltene over supported molybdenum catalysts.** Song, Chunshan (Osaka Univ., Faculty of Engineering, Osaka. Japan); Nihonmatsu, Toshihiko; Hanaoka, Koji; Nomura, Masakatsu. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Two kinds of asphaltene belonging to coal and another kind belonging to bitumen were used as samples and their properties were compared. Catalysts to be used for hydrocracking of such asphaltenes were also compared. As the result of elemental analysis and NMR analysis, coal-asphaltene, compared with bitumen-asphaltene, had less molecular weight, lower H/C, higher rate of O and N, and more aromatic hydrogen. In the hydrocracking test without catalyst, benzene insoluble matter(BI) was left about 1% in bitumen-asphaltene, but 9-12% was left in coal-asphaltene. Consequently, it was found that coal-asphaltene was hard to dissolve. Two kinds of S-NiMo catalyst with different pore sizes(the average pore size of alumina support: 6nm and 28nm) were used to examine the hydrocracking reaction of coal-asphaltene. As a result, less BI was left in both solvents such as tetralin and decalin when the catalyst with greater pore size was used. This indicated that the catalyst with larger pore size was favorable for hydrocracking of asphaltene which consisted of huge molecule. 6 refs., 3 figs., 2 tabs.

6652 (FSJ–8902, pp. 242-245) **Catalytic dealkylation of alkylbenzene and coal derived oil with steam-(Part 2). Effect of K_2 O addition on Fe_2O_3/NIO catalyst.** Yamamoto, Mitsuyoshi (Government Industrial Development Lab., Sapporo,, Japan); Maekawa, Yosuke; Kotanigawa, Takeshi. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

The effect of Fe_2O_3/NiO as a catalyst for dealkylation of coal derived oil with steam was described in the previous report. In this report, the effect of K_2CO_3 was studied by adding 0-0.5% of it to the catalyst. Toluene was used as a model compound, and its reaction with steam was investigated. As a result, it was found that the K_2CO_3 added catalyst greatly improved not only the yield of benzene generated by dealkylation but also the durability of the catalyst itself. Under the optimum condition of reaction determined on toluene (temperature: 480°C, K_2CO_3 addition: 0.3%, molar ratio of water addition: 5.1), fraction of coal oil derived from Illinois coal treated with steam, and the products from this reaction were analyzed. As a result, it was made clear that the K_2CO_3 added catalyst promoted preferential generation of benzene and toluene compared to the catalyst without addition. It is because the K_2CO_3 addition suppressed the effect of the Fe_2O_3/NiO catalyst to dehydrogenerate tetralin and indane. 1 ref., 3 figs., 2 tabs.

6653 (FSJ–8902, pp. 265-266) **Solvent extraction of nitrogen-compounds in coal liquids.** Kodera, Yoichi (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Ukegawa, Koji; Takahashi, Tadao. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

In order to find out the effective process to extract useful heterocyclic compounds containing nitrogen in coal liquids, conditions of solvent extraction using methanol-water were studied. Methanol was added to intermediate fraction of coal liquid(stock oil). After shaking the mixture, water was added. Then, nitrogen compounds were extracted into water-methanol phase together with methanol. The extraction rate of nitrogen compounds was determined by the analysis value of nitrogen content in the oil phase, and the selectivity of

each nitrogen compound was determined by gas-chromatographic analysis of water-methanol phase. The extraction rate of nitrogen compounds increased with the amount of methanol addition to stock oil, however, in order to obtain the excellent selectivity on each nitrogen compound such as quinoline and isoquinoline, the ratio of ethanol addition to stock oil had to be adjusted to the proper value for each compound. The total of each selectivity of nitrogen compounds became largest when two volumes of methanol were added to one volume of stock oil, and the ratio then was assumed as the optimum addition ratio of methanol. As a result of the similar experiment of water addition, it was found to be preferable that the addition volume water was equal to stock oil volume. 2 figs.

6654 (FSJ–8902, pp. 267-270) **Study on the chromatographic analysis of the brown coal-derived preasphaltenes. Application of the reversed phase liquid chromatography.** Masuda, Kaoru (Kobe Steel, Ltd., Tokyo, Japan); Okuma, Osamu; Saito, Kaizaburo; Okazaki, Keishin; Matsumura, Tetsuo. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

CLB(Coal Liquid Bottom) is the distillation residue of the produced liquid of primary hydrogenation in the two stage liquefaction process for brown coal. The property of preasphaltene in CLB was studied with the reversed phase liquid chromatography(RPLC). Benzene insoluble-pyridine soluble(BI-PS) in CLB was used as a sample, and N-methyl-2-pyrrolidone(NMP) as an eluent. Two peaks, A and B, appeared at the chromatogram of BI-PS. Each of LiBr, pyridine, and Bu_4 NOH was respectively added to the eluent NMP in order to analyze the behavior of peaks A and B. As a result, it was found that the constituent applied to the peak A was produced by the dissociation of acid material in the eluent. Moreover, the reason why two peaks appeared separately was assumed. That is, the one was to be ionized and the other was not due to the difference in the intensity of polarity of the constituent. It was also recognized that the constituent applied to the peak A decreased when the temperature in the primary hydrogenation reaction was raised or the reaction time was extended. 5 refs., 5 figs., 1 tab.

6655 (FSJ–8902, pp. 271-274) **Studies of hydroaromatic structure in coal hydrogenation oil by means of dehydrogenation.** Kaneko, Masahito (Hokkaido Univ., Faculty of Engineering, Sapporo, Japan); Yokoyama, Susumu; Sato, Masaki; Sanada, Yuzo. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

In order to clarify the chemical structure of hydroaromatic compound included a lot in coal hydrogenation oil, dehydrogenation of coal liquid was performed and changes in the chemical structure of constituents before and after dehydrogenation were investigated by the GC-MS method and other methods. SRC-2 used as a sample was divided into each compound according to the number of aromatic rings by the HPLC method. Then, naphthalene type bicyclic aromatic fraction(Fr-D1) and others were obtained. Each one of divided fraction was dehydrogenated at 410°C with Pd catalyst. From the analysis on mass chromatogram of Fr-D1, distribution of compound types based on the z number was figured, and distribution changes before and after dehydrogenation were examined. Moreover, materials that did not react in the first hydrogenation were hydrogenated again. Then, mass chromatograms before hydrogenation and after second hydrogenation were compared. As a result, major constituent of hydroaromatic compound in SRC-2 was assumed to be a type containing naphthenic rings of pentatomic rings. 6 figs.

6656 (FSJ–8902, pp. 275-278) **Studies on the removal of heteroatomic compounds (1). Separation and determination of heteroatomic compounds in synthetic crude naphthas by column adsorption chromatography.** Yoshida, Tadashi (Governmint Industrial Development Lab., Hokkaido, Sapporo, Japan); Maekawa, Yosuke; Chantal, P.D.; Sawatzky, H. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

In order to remove and recover heteroatomic compounds in naphthas, methods for separation and analysis by absorption were examined. Naphthas obtained by the CANMET hydroprocess and several other processes were used as samples. Then it was attempted to absorb and separate each of O-, N-, and S-compounds selectively through two-stage treatment. When naphtha was first put through the basic alumina column, at the same time the weight ratio of naphtha/absorbent was rationalized, N- and O-compounds were selectively absorbed and S-compound was desorbed. Naphtha, from which N- and O-compounds were thus removed, was then put through the silica gel column so that S-compound could be absorbed and separated. N-compound fraction recovered with solvent was separated by gas chromatography. Then, each group of pyridine, pyrrole, and others was eluted in order. Therefore it was found to be possible that N-compound was determined into each type. Moreover, heteroatomic compounds in each naphtha sample were analyzed, and the results were studied in relation to the materials and production processes. 1 ref., 4 figs., 3 tabs.

6657 (GAO/RCED–89-153) **Synthetic fuels: An overview of DOE's ownership and divestiture of the Great Plains project.** General Accounting Office, Washington, DC (USA). Resources, Community and Economic Development Div. 1989. 48p. Available from US General Accounting Office, PO Box 6015, Gaithersburg, MD 20877.

In January 1982, the Department of Energy guaranteed a loan for the construction and startup of the Great Plains project. On August 1, 1985, the partnership defaulted on the $1.54 billion loan, and DOE acquired control of, and then title to, the project. DOE continued to operate the plant, through the ANG Coal Gasification Company, and sell synthetic fuel. The DOE's ownership and divestiture of the plant is discussed.

6658 (ORNL/FMP–87/4, pp. 295-320) **Corrosion of alloys in mixed-gas and combustion environments.** Natesan, K. (Argonne National Lab., IL (USA)). Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Extensive research has been performed over the past 10 years to evaluate the compatibility of engineering materials and model alloys in oxygen-sulfur mixed-gas environments that are relevant to both coal gasification and coal combustion schemes. This paper briefly summarizes the available information to give insight into the development of protective oxide scales in high-temperature alloys exposed to complex gas atmospheres. Results from ongoing research activities on the corrosion of high-chromium alloys are used to examine the roles of several factors such as cation and sulfur transport through the scales, mechanical effects, sulfur segregation, and time-dependent morphological changes in the scale, in the onset of break away corrosion in structural alloys. From current knowledge of the combustion and gasification environments and of the behavior of structural alloys exposed to them, several requirements that a suitable alloy should meet are presented, and possible avenues for modification of alloys to achieve improved corrosion resistance are discussed.

6659 (ORNL/FMP–87/4, pp. 321-342) **Corrosion-resistant scales on iron-based alloys.** Hsu, H.S. (Oak Ridge National Lab., TN (USA)). Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Corrosion tests were conducted at 800°C on iron-based alloys in a H_2-H_2S-H_2O-Ar gas mixture with $P_{S_2} = 10^{-6}$ and $P_{O_2} = 10^{-20}$ atm that simulates severe coal gasification environments. Al_2O_3-forming iron-based alloys were more corrosion resistant than Cr_2O_3-forming iron-based alloys in this environment. Rapid sulfidation of Al_2O_3 forming iron-based alloys with and without preoxidation proceeded initially by nucleation and growth of chromium-rich sulfides and later formation of iron-rich sulfides. To increase the corrosion resistance of Al_2O_3 forming iron-based alloys, the formation of fast-growing sulfides, such as CrS, FeS, and sulfide mixtures

containing CrS and/or FeS, should be minimized or avoided completely. A new iron-based alloy developed in this study has shown very good corrosion resistance. Only small metal sulfide particles formed on the alloy surface with no observable internal sulfidation.

6660 (ORNL/FMP–87/4, pp. 343-355) **Corrosion mechanisms of coal combustion products on alloys and coatings.** Kim, G.M. (Univ. of Pittsburgh, PA (USA)); Gulbransen, E.A.; Meier, G.H. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

The ferrous alloys (Fe-18Cr-6Al, Fe-18Cr-6Al-lTi, Fe-18Cr-6Al-lHf, Fe-25Cr and Fe-20Si) were studied between 700 and 1100°C in an oxidizing (air or H_2/H_2O) atmosphere. Then the breakdown of preformed oxide scales on these alloys was studied in a sulfidation/oxidation ($H_2/H_2O/H_2S$) atmosphere at the same temperatures. The resistance to isothermal oxidation, thermal cycling in air at 950°C, and sulfidation/oxidation increases in the order of SiO_2 former $>Al_2O_3$ former $>Cr_2O_3$ former. The addition of Ti to Fe-18Cr-6Al improves the resistance to cyclic oxidation and sulfidation/oxidation at 950°C. The addition of Hf to Fe-18Cr-6Al improves cyclic oxidation resistance but also provides rapid transport paths for sulfur through the scale. The breakdown of Cr_2O_3 films on Fe-25Cr initiates at the scale/gas interface. Silica scales formed on Fe-20S1 are extremely resistant to sulfur penetration but may break down eventually due to the outward transport of Fe through the scale.

6661 (ORNL/FMP–87/4, pp. 384-396) **The effects of microalloy constituents, surface treatment and oxidation conditions on the development and breakdown of protective oxide scales.** Srinivasan, V. (Universal Energy Systems, Inc. Dayton, OH (USA)). Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Major material problems exist from gaseous corrosion induced by the multi oxidant environment in 500 to 700° temperatures in coal gasification/liquefaction and fossil fuel type plants. Components made of ferritic or austenitic steels have adequate mechanical strength at these temperatures but corrosion resistance depends on the formation of continuous scales with protective Al_2O_3 or Cr_2O_3 layers, which does not last long. The degradation processes depend on the scale microstructure, morphology and adhesion, substrate chemistry and microstructure and the environment. Investigations of the oxidation and corrosion behavior of Fe, Ni- and Co-base alloys at temperatures above 850° revealed the beneficial effects of oxygen active elements and oxide dispersoids on scaling. Minor addition of these elements or dispersoids improve the oxidation resistance by enhancing the scale adhesion and modifying the scale morphology and growth process and are likely to provide resistance to scale breakdown and the transport of corrosive reactant. Studies at temperatures above 850 °C will not extrapolate to a meaningful understanding of conditions in the 500 to 700° temperature range. Kinetic factors are likely to dominate the oxidation/corrosion behavior in this temperature range with possible changes in the mechanisms of reactant transport across scale and in the substrate. This program proposes to investigate the effect of additions of several microalloy constituents, their concentration, method of incorporation, surface pretreatment and the oxidizing conditions on nucleation, growth and breakdown of Al_2O_3 scales on ferritic and austenitic steels. The ultimate goal is to identify the factors that lead to corrosion resistant micro structures and morphology of protective oxide scales and implement the findings in alloy development.

6662 (ORNL/FMP–87/4, pp. 397-421) **Mechanisms of galling and abrasive wear.** Ives, L.K. (National Bureau of Standards, Gaithersburg, MD (USA)); Peterson, M.B.; Whitenton, E.P. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Galling is a severe form of wear which has been recognized as a serious problem affecting the operation of control valves an other components used in fossil energy conversion systems. Recent results obtained in a program of research aimed at advancing the basic understanding of the process of galling are presented. The galling test method and a method which has been developed to measure quantitatively the amount and character of galling damage are described. Data on the galling behavior of pure metals, experimental alloys, and commercial alloys are presented. The influence of hardness, crystal structure, stacking fault energy and other materials properties are discussed.

6663 (ORNL/FMP–87/4, pp. 422-451) **Particle erosion in turbulent flow past tube banks.** Humphrey, J.A.C. (Univ. of California, Berkeley (USA)); Schuh, M.J.; Schuler, C.; Schweitzer, M.O. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Measurements and calculations are reported for particle-laden flows past single tubes and two in-line tubes. The measurements are for particle flux in the turbulent flow regime. This is a more fundamental quantity to determine than erosion since the latter is complicated by the nature of the particle-surface interaction and the material properties. The calculations are for fluid and particle motion in the laminar regime. They have required the development and testing of a body-fitted coordinate numerical procedure for determining fluid motion past single tubes, two in-line tubes and a tube in an infinite tube bank. Current work is addressing the extension of the numerical procedure to turbulent flow.

6664 (ORNL/FMP–87/4, pp. 452-466) **Alkali attack of coal gasifier refractory linings.** Brown, J.J. Jr. (Virginia Polytechnic Institute and State Univ., Blacksburg (USA)). Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Thermodynamic calculations were used to study the alkali and/or alkali-sulfur species present under coal gasifying conditions and the phases present when alkali and sulfur react with the calcium aluminate cement in the gasifier refractory lining. Phase maps were prepared covering temperatures from 800K to 1900K and pressures from ambient to 10.4 MPa. From a thermodynamic point of view, alkali reactions appear to be inevitable when refractories of the $CaO-Al_2O_3-SiO_2$ system are exposed to alkali-containing coal gasifier environments. Because the total energy of the system is lowered by the formation of alkali compounds, the compounds formed are usually much less dense than the original refractory. The attack may be retarded by slowing the rates of reactions by elevating operating pressures rather than temperatures, minimizing refractory porosity, and maximizing refractory bonding phase maturity prior to initial gasifier operation.

6665 (ORNL/FMP–87/4, pp. 467-491) **Studies of materials erosion in coal conversion and utilization systems.** Levy, A.K. (Lawrence Berkeley Lab., CA (USA)). Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Investigations have been completed to determine how the mechanical and physical properties of iron, nickel, and cobalt base alloys could be modified by composition changes and mechanical or thermal treatments to improve their solid particle erosion resistance. It has been determined that essentially all structural alloys behave in a very similar manner in near room temperature erosion regardless of their strength or other property levels. No definitive alloy selection criteria for erosion have been established. The addition of hard, carbide particles to metal matrices does not improve erosion resistance until approximately 80 vol. % of the composite is carbide particles. In combined erosion-corrosion of the type that occurs in coal burning energy generation equipment it is the nature of the scales that form on the metals and not the erosion behavior of the metals that govern metal wastage. Relatively low alloy steels with

scale morphologies that are segmented in nature have much lower metal wastage rates than higher alloy content steels whose scales may be more consolidated.

6666 (ORNL/FMP–87/4, pp. 492-516) **Study of particle rebound characteristics and material erosion at high temperatures.** Tabakoff, W. (Univ. of Cincinnati, OH (USA)). Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

The Laser Doppler Velocimeter (LDV) system was used to measure the rebounding characteristics of 15 micron mean diameter fly ash particles impacting several target materials. The rebounding velocities and angles were determined for 410 stainless steel, 6Al-4V titanium, INCO 718, RENE 41, AM355, and L605 cobalt target materials at different impact angles. In addition, an erosion study was conducted to measure the erosion rate for the AM355 target material impacted by fly ash and silica sand particles. The effect of the parameters on erosion was investigated: particle sizes, velocity, impingement angle and temperature.

6667 (ORNL/FMP–87/4, pp. 517-534) **A study of erosive particle rebound parameters.** Kosel, T.H. (Univ. of Notre Dame, IN (USA)); Sriram, T.S. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

This paper describes a research project designed to provide a systematic investigation of the effects of materials properties and experimental variables on the rebound directions and velocities of erodent particles. The primary purpose of the project is to develop the capability to accurately predict rebound parameters. The general approach is to develop computer models for the impact of spherical and angular particles, and to compare the predictions with experimental measurements of both single and multiple impact rebound parameters. Initial results are discussed for computer modeling of the impact of spherical particles.

6668 (ORNL/FMP–87/4, pp. 535-552) **In-situ scanning electron microscopy studies of the erosion of alloys.** Keiser, J.R. (Oak Ridge National Lab., TN (USA)). Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Impacts by erosive particles result in the high strain rate deposition of an appreciable amount of energy into the deformed volume of the target material. This energy can be manifested as local heating; softening or even melting has been observed in many materials. Hardening caused by the high strain rate deformation has also been reported for strain hardenable materials. The effect of individual impacts on the surface of selected materials was determined for 343-μm-diam tungsten carbide balls impacting at about 30 m/s and 30° incidence angle. A mechanical properties microprobe was used to measure the hardness of the crater bottom, and just below the original surface. Strain hardening but no evidence of softening was observed in these materials.

6669 (ORNL/FMP–87/4, pp. 555-577) **Investigation of candidate alloys for advanced steam cycle superheaters and reheaters.** Swindeman, R.W. (Oak Ridge National Lab., TN (USA)); Goodwin, G.M.; Maziasz, P.J. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Screening tests were performed on a series of modified type 316 stainless steels and modified 800H alloys to identify candidates for use as tubing in advanced boiler superheaters/reheaters producing steam at 650°C (1200°F) and 35 MPa (5000 psi) pressure. Alloy evaluations included fabricability, tensile and creep behavior, weldability, metallurgical stability, and response to chromizing. The modified type 316 stainless steels exhibited sufficient strength and ductility to meet a target design strength of 60 MPa at 700°C but were difficult to weld and had very poor oxidation resistance. The compositions based on alloy 800H were weaker than the modified type 316 stainless steels and exhibited similar problems in regard to weldability. All alloys were stronger when cold worked to small strains (2 to 10%). The most promising compositions contained low levels of phosphorus. Based on the results of the screening tests, compositions were selected for the production of small heats of tubing.

6670 (ORNL/FMP–87/4, pp. 578-592) **The high temperature deformation and microstructural stability of advanced steam cycle materials.** Carolan, R.A. (Cornell Univ., Ithaca, NY (USA)); Coulombe, B.; Li, C.Y. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

A series of modified austenitic type AISI 316 stainless steels have been evaluated, in terms of high temperature flow strength, for potential use in fossil energy plants. This series includes Ti/V/Nb stabilized 316 steels, and two copper modified 316 steel one stabilized with vanadium, titanium, and niobium, and a second stabilized with titanium and niobium. The effects of thermo-mechanical pretreatment on alloy flow strength have also been investigated to optimize alloy strength before use. Load relaxation testing has been the primary technique used in this investigation.

6671 (ORNL/FMP–87/4, pp. 647-675) **Development of a design methodology for high-temperature cyclic application of materials which experience cyclic softening.** Marriott, D.L. (Univ. of Illinois, Urbana (USA)); Stubbins, J.F.; Leckie, F.A.; Handrock, J.L.; Kschinka, B. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Consideration is being given to using low alloy steels, such as 2.25 Cr 1 Mo steel, in a heat treated form to produce a bainitic micro- structure with improved short term strength compared with the more commonly used annealed form. It has been found, however, that the bainitic structure softens significantly under cyclic loading, as a secondary effect of which the creep strength is also shown to be reduced. Tests in which periodic load reversals were superimposed on a steady load creep test have shown reductions of creep life of an order of magnitude or more. One major mitigating factor is that it appears that cyclic softening only occurs in material subjected to significant strain reversals. In a typical pressure vessel such conditions are only achieved typically in localized areas such as notch-like details and areas experiencing high cyclic thermal gradients. The investigation described here is aimed at determining the effect of local cyclic softening on residual strength of components. This has been done by performing load controlled tests on two types of notched bars, a relatively blunt Bridgman notch with an elastic SCF of 1.6, and a sharper Vee-notch with an SCF of 4.4, together with a small number of uniaxial specimens as controls. Some theoretical results, which attempt to characterize component behavior in a very generalized way, are described, and plans for developing design rules are discussed briefly.

6672 (ORNL/FMP–87/4, pp. 676-682) **Protective coatings and claddings: Application/evaluation.** Gopalsami, N. (Argonne National Lab., IL (USA)); Ellingson, W.A.; Roberts, R.A. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Nondestructive evaluation (NDE) plays an important role in the development of coatings/claddings for heat recovery systems of coal gasifiers. It must characterize coating defects and establish a relationship between the nature of the defects and observed corrosion behavior in typical heat recovery system environments. A review of potential NDE methods has been made with reference to the type of coatings in this application. The review focuses, in particular, on aluminized, chromized, and simultaneously aluminized/

chromized coatings which are produced by pack-diffusion processes on low-alloy and carbon steels. A candidate NDE technique must ideally be capable of detecting fine cracks, inclusions, voids, and Al/Cr concentration profiles. The NDE methods reviewed are thermal-wave imaging, scanning acoustic microscopy, backscattered surface waves, eddy-current testing and X-ray fluorescence. Although each of these methods appears to have applicability in one respect or the other, we have made an initial selection of thermal-wave imaging and backscattered surface-wave techniques for experimental investigation. Some preliminary results on these methods will be presented.

6673 (ORNL/FMP–87/4, pp. 683-696) **Development of Fe3Al-based aluminides.** McKamey, C.G. (Oak Ridge National Lab., TN (USA)); Liu, C.T.; David, S.A.; Horton, J.A.; Cathcart, J.V. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Iron aluminides based on Fe_3Al possess many attractive properties for structural use. However, limited ductility at ambient temperatures and a sharp drop in strength above 600°C restrict their use as structural materials. The goal of the present study is to develop Fe_3Al-based aluminides with optimum combinations of strength, ductility, and corrosion resistance for use as hot components in advanced fossil energy conversion systems. From a study of the properties of alloys of 24 to 30 at. % Al, it has been determined that the most promising alloy for further development is Fe-28 at. % Al. A discussion of the effect of aluminum concentration on mechanical properties is included in this paper. Initially, 0.5 wt % TiB_2 was added for grain refinement. It has since been determined that these precipitates are deleterious to the weldability, and for future alloy development they will not be added. Alloy additions, have been shown to improve both the high-temperature strength and room-temperature ductility. Results of weldability and tensile and creep tests, as well as the present status of oxidation and aqueous corrosion tests, are reported.

6674 (ORNL/FMP–87/4, pp. 697-714) **Joining of advanced aluminides.** Clark, D.E. (Idaho National Engineering Lab., Idaho Falls (USA)). Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

The weldability of four Ni_3Al-8% Cr alloys (IC-218, IC-221, and two low-Zr modifications) was investigated. Solidification segregation during base metal production decreases weldability by creating low-melting regions susceptible to hot cracking during welding. Extrusion, hot rolling, and annealing homogenize the base metal microstructure, solving this problem. Weldability was evaluated with the GTAW process and HAZ simulation (Gleeble testing) as a function of Zr content, preheat temperature, and weld travel speed. Weld cracking occurred in the fusion zone; no cracks originated in base material or HAZ. Cracking increased with Zr content at low Zr levels, increased with welding speed, and decreased with preheat. At higher Zr levels, hot cracking, possibly due to a Zr-Ni eutectic, was severe. An interdendritic phase present at higher welding speeds, apparently β', is strongly enriched in Zr.

6675 (ORNL/FMP–87/4, pp. 715-717) **HEDL-2 – Investigation of electro-spark deposited coating for protection of materials in sulfidizing atmospheres.** Johnson, R.N. (Westinghouse Hanford Company, Richland, WA (USA)). Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

The objective of this program is to develop candidate coatings, using the electro-spark deposition (ESD) process, for the protection of materials in sulfidizing atmospheres typical of fossil energy applications. Coatings of interest include FeCrAlY, NiCrAlY, chromium, aluminum, niobium, chromium carbide, and titanium diboride. Materials to be protected include low alloy steels, Alloy 800, Type 310 stainless steel and Hastelloy C.

6676 (ORNL/FMP–87/4, pp. 718-733) **Investigation of weldability of ductile aluminides.** Maquire, M.C. (Oak Ridge National Lab., TN (USA)); Edwards, G.R.; David, S.A. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Ni_3Al and alloys based on that composition possess desirable high temperature strength properties. The recent advances in imparting ductility to these alloys by micro alloying with boron is not effective at high temperatures, where these alloys fracture in a brittle, intergranular fashion. Consequently, welds made with these alloys are subject to heat-affected zone (HAZ) cracking. This work concerns the improvement of weldability and hot ductility of these alloys through microstructural refinement of the grain structure, and further refinement by production of an anti phase domain structure.

6677 (ORNL/FMP–87/4, pp. 734-756) **Consolidation of rapidly solidified nickel aluminide powders.** Wright, R.N. (Idaho National Engineering Lab., Idaho Falls (USA)); Flinn, J.E. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

The microstructure and mechanical properties of boron microalloyed rapidly solidified Ni-22.6Al and Ni-18.4Al-8.3Cr powders that have been consolidated by hot extrusion and hot isostatic pressing have been investigated. Vacuum gas and centrifugal atomization have both been found to produce relatively clean powders with a thin oxide that does not hinder bonding during consolidation. Extruded materials produced from the powders have very fine grain sizes which resist coarsening at elevated temperatures. The powder materials have good room temperature strength and ductility and exhibit relatively little increase in flow stress with increasing temperature. Both of the alloys are very strain rate sensitive above 900°C. The Cr-containing alloy is found to exhibit superplastic behavior. The properties of the hot isostatically pressed material are very sensitive to the consolidation parameters and post-consolidation heat treatment.

6678 (SAND–89-7146C) **Economics of advanced indirect liquefaction processes.** Tomlinson, G.; El Sawy, A.; Gray, D. Sandia National Labs., Albuquerque, NM (USA). [1989]. 27p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-891131–1: Indirect liquefaction contractors review meeting, Pittsburgh, PA (USA), 13-15 Nov 1989). Order Number DE90003920. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The objectives of this work are to estimate the cost of production of high quality liquid transportation fuels from advanced coal-based indirect liquefaction processes and to determine the economic impact of coproducing electric power using the once-through Fischer-Tropsch (OTFT) concept. 12 refs., 12 figs., 9 tabs.

6679 Novel dispersed-phase catalytic approach to coprocessing. Cugini, A.V. (Pittsburgh Energy Technology Center, PA (USA)); Ruether, J.A.; Cillo, D.L.; Krastman, D.; Smith, D.N.; Balsone, V. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 6-19 (1988). (CONF-8806312–: Symposium on coal-derived fuels - coprocessing, Toronto (Canada), 5-10 Jun 1988).

The Pittsburgh Energy Technology Center (PETC) is currently testing a new process concept for catalytically coprocessing a mixture of coal and petroleum-derived residual oils. The catalyst used in this process is molybdenum added directly to the reactor as an aqueous solution. Recent results are presented for product yield structure obtained in a 1-liter semibatch reactor. A discussion is also given for some recent findings obtained from coprocessing studies in a 1-liter continuous reactor system. An important economic advantage in using this process can be gained if recovery of the dispersed catalyst from the product residue is demonstrated. A discussion is provided of an approach to catalyst recovery that does not require complicated processing steps and uses relatively inexpensive reagents. Results are presented from preliminary testing of

the recovery process that indicate it is feasible to efficiently recover the catalytically active material for reuse in the process.

6680 The chemical origin of synergy in liquefaction and coprocessing. McMillen, D.F. (SRI International, Menlo Park, CA (USA)); Malhotra, R.; Tse, D.S.; Nigenda, S.E. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 58-64 (1988). (CONF-8806312--: Symposium on coal-derived fuels - coprocessing, Toronto (Canada), 5-10 Jun 1988).

Recently there have been several reports of coal liquefaction illustrating the interactive effect of various components. The authors have used these results in conjunction with an improved mechanistic mode4l for coal liquefaction to help shed some light on the chemical origin of such interactive effects. Specifically, they show that the various H-transfer processes that they have hypothesized as leading to bond cleavage by solvent-mediated hydrogenolysis clearly fall in the second category of reaction type. As previously discussed most of these processes require both a hydrogen donor species and an acceptor species in order to form the active H-transfer intermediate, a cyclohexdienyl carrier radical, which can transfer hydrogen to engender cleavage of even strong bonds. In the following paragraphs, the authors summarize two of the more recent and more striking examples of synergism. One of these uses only nonhydroaromatic donors and the other hydroaromatic donors. They then discuss, in qualitative terms, how a coal-liquefaction picture that includes strong bond hydrogenolysis mediated by solvent carrier radicals can easily accommodate the liquefaction results. The case involving hydroaromatic solvents is more amenable to mechanistic modeling, and for this case they compare cleavage rates predicted by the model with the actual liquefaction results. Finally, they extend the mechanistic insight gained in rationalizing the positive interaction among solvent components in coal liquefaction to account for the interactive effects reported for coprocessing.

6681 Evaluation of the interactive chemistry of coal-petroleum systems using model and actual reactants. Curtis, C.W. (Auburn Univ., AL (USA)); Chung, Wook Jin. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 65-70 (1988). (CONF-8806312--: Symposium on coal-derived fuels - coprocessing, Toronto (Canada), 5-10 Jun 1988).

The coprocessing of coal with petroleum residuum simultaneously liquefies coal and upgrades petroleum residuum into higher value products. However, coal and petroleum residuum manifest very different chemical properties with coal being more aromatic with a H/C ratio of 0.6 - 0.8 and petroleum residuum more aliphatic with a H/C ratio of 1.4 to 1.6. Although a number of studies have demonstrated the feasibility of coprocessing on the basis of product selectivity and metals reduction, the interactive chemistry involved between the coal and petroleum materials during coprocessing has not yet been determined. In this study, the interactive chemistry between coal and petroleum molecules has been examined: first by using model compound types representative of coal and residuum and then by combining the model systems with Illinois No. 6 coal and Maya topped long residuum (TLR). The model systems, composed of naphthalene (NAPH) representing aromatics, 1,4-dimethylcyclohexane (DMC) representing saturated compounds, phenol (PN) representing phenolics, benzothiophene (BZT) representing sulfur compounds, and quinoline (QN) representing nitrogen compounds, were reacted thermally and catalytically using a Shell 324 $NiMo/Al_2O_3$ catalyst. The model systems were reacted individually and then combined together to ascertain the effect of the different components on the thermal and catalytic reactions of the different model systems. Illinois No. 6 coal and Maya TLR were each, respectively, added to the model compound systems and reacted thermally and catalytically.

6682 Coal/oil coprocessing mechanism studies. Cugini, A.V. (Pittsburgh Energy Technology Center, PA (USA)); Lett, R.G.; Wender, I. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 71-88 (1988). (CONF-8806312--: Symposium on coal-derived fuels - coprocessing, Toronto (Canada), 5-10 Jun 1988).

Initial coprocessing studies, performed to provide a basis for larger scale tests of coprocessing options using batch one-liter autoclave and continuous hydrotreater facilities at PETC, are described. Areas investigated included the response of coal and petroleum resid combinations to processing under thermal hydrotreatment conditions, the means of increasing the conversion of coal, and the nature of resid demetalation effects. The petroleum resids possessed rather low donable-hydrogen capacities, and the interactions between the resids and coals are weak with respect to promoting formation of liquid products under thermal conditions. Maya ATB was superior to Boscan ATB or North Slope VTB for the conversion of Illinois No. 6 coal to liquid or soluble products. The Maya ATB/Illinois No. 6 coal system responded favorably to the addition of low concentrations of a highly dispersed, unsupported molybdenum catalyst. Extensive demetalation of the liquid product was observed and was a function of the amount of coal added. Results obtained using different coal and resid combinations, under thermal and catalytic conditions, and in the presence of various additives, imply that an absorptive mechanism is operative. The primary interactions leading to demetalation appear to be between the metal complexes of the resid and the insoluble carbonaceous coal-derived material. Demetalation of the liquid product was not observed to be dependent on conversion of the organically complexed metal in the resids to inorganic form.

6683 Behavior of ash-forming mineral matter in coal during chemical cleaning with molten caustic. Kaushik, S.M. (Iowa State Univ., Ames (USA)); Norton, G.A.; Markuszewski, R. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 18-27 (1988). DOE Contract W-7405-ENG-82. (CONF-8806316--: Ash chemistry of coal, Toronto (Canada), 5-10 Jun 1988).

Coal-derived mineral matter, obtained by low-temperature ashing of Kentucky No. 11 coal, as well as mineral-grade samples of quartz, illite, kaolinite, and pyrite, were treated with various ratios of molten caustic (NaOH, KOH, and 1:1 NaOH-KOH mixtures) at 370 C for 1-2 hours to study the nature of reaction products obtained under the conditions of chemical cleaning of coal by the molten caustic leaching (MCL) process. Under these conditions, most of the reactions of minerals with caustic were very rapid, being complete in less than 10 minutes. The reaction products were characterized by x-ray diffraction, thermogravimetric analysis, atomic absorption spectrophotometry, and chemical analysis. The nature of these products was related to the stoichiometry of the reaction and was useful in explaining the process chemistry and in developing regeneration schemes for the spent caustic.

6684 Formation and growth of coal ash agglomerates. Carty, R.H. (Institute of Gas Technology, Chicago, IL (USA)); Mason, D.M.; Kline, S.D.; Babu, S.P. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 34-41 (1988). (CONF-8806316--: Ash chemistry of coal, Toronto (Canada), 5-10 Jun 1988).

The overall aim of the IGT ash chemistry studies is to predict the behavior of the coal ash in a fluidized-bed gasifier on the basis of a minimum analysis of the characteristics of the feed coal mineral matter and the operating conditions of the gasifier. In this study the objective was to correlate the composition and distribution of the mineral matter for five eastern and two western coals to the behavior of their ash in a laboratory gasifier. Coals were sought whose ash composition would reflect the full range of the most important variable for agglomeration, the average concentration of pyrite relative to the siliceous minerals. The concentration of calcium minerals - typically calcite - is probably next most important variable. Accordingly, the authors selected four U.S. bituminous coals covering a wide range of iron oxide and only small amounts of calcium oxide in the ash. An Illinois No. 6 Seam coal with high calcium oxide and low iron oxide, a western bituminous (York Seam), and a subbituminous coal (Rosebud Seam) were also selected for testing. The mineral matter in each coal was characterized by: determination of the concentration of major and minor oxides in the ash; Moessbauer analyses to measure the concentration by type of the iron compounds present; and mineralogical analyses by computer-assisted scanning electron microscopy (SEM). Typically, in the eastern bituminous coals, iron is present as pyrite and its oxidation products, namely sulfates. In New York coal, the iron is mainly present in chamosite and in siderite.

6685 Stability of chromium oxide scales in oxygen-sulfur containing environments at elevated temperatures. Natesan, K.

(Argonne National Laboratory, IL (USA)); Baxter, D.J. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 29 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Structural alloys rely upon the presence of protective surface oxide films to provide adequate resistance to environmental degradation at elevated temperatures. For alloys in which Cr is a major constituent, protection can usually be afforded by a Cr-rich usually Cr_2O_3 surface scale. The oxide, Cr_2O_3, is stable at oxygen and sulfur potentials below those normally experienced in coal conversion/gasification processes. In practice, however, an excess of oxygen, above the level defining thermodynamic equilibrium between Cr_2O_3 and CrS, is necessary for Cr_2O_3 to be formed and maintained as a surface scale. Tests on Fe-Cr-Ni-base alloys in (O_2 + S_2)-containing environments with widely varying reaction potentials, in the temperature range from 650 to 1000 C and with exposure times of up to 5000 h, have been used to evaluate the influence of the chemistries of the alloy and of the gaseous environment on corrosion behavior. The stable oxide formers Zr and Nb promote the growth and maintenance of Cr oxide scales, whereas Ti has only a minor influence and Mn promotes oxide breakdown. Structural analysis of preoxidized alloys after exposure to a sulfur-containing gas has been used to identify the mechanism(s) of breakdown of Cr oxide scales.

6686 Corrosion of ceramics in heat exchanger applications. Easler, T.E. (Argonne National Laboratory, IL (USA)); Poeppel, R.B. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 29 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The gasification of domestic coals in the US has become increasingly attractive as a source of clean energy, as a result of the decreasing availability of natural gas and petroleum. The efficiency of conversion of the total coal energy is an important consideration in this process. Approximately 25% of the coal energy is released as waste or by-product heat during gasification; therefore, the use of metallic or ceramic heat-exchanger/recuperator systems to recover this energy is desirable. The most aggressive, high-temperature areas of the coal gasifier demand the use of structural ceramic materials for heat exchanger applications. The materials must withstand temperatures in the range 1200-1400 C, oxygen partial pressures of approximately 10^{-12} to 10^{-14} atm, and the presence of corrosive gases and molten slag. Research in two major areas is being undertaken to evaluate potential ceramic heat exchange materials and a heat exchanger design. A ceramic heat exchanger module has been designed, fabricated, and assembled. Preliminary testing of the module will be in a combustion environment. Corrosion testing of various structural ceramic materials is being carried out in a simulated coal gasification environment. Synthetic coal slags are being applied to the specimens to study their corrosive behavior. Conventional metallographic techniques are used to investigate slab penetration and material degradation. Effects of exposure on mechanical properties are also evaluated.

6687 Stable carbon isotope analysis of coal/petroleum coprocessing products. Winschel, R.A. (Consolidation Coal Company, Library, PA (USA)); Burke, F.P. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 114-121 (1988). (CONF-8806312–: Symposium on coal-derived fuels - coprocessing, Toronto (Canada), 5-10 Jun 1988).

Coprocessing involves the simultaneous upgrading of coal and petroleum resid by catalytic hydroconversion. To obtain a kinetic/mechanistic description of the process, it is useful if not necessary to be able to distinguish the relative contributions of coal and petroleum to the product mixtures. In this paper, the method of stable carbon isotope ratio analysis is shown to be sufficiently sensitive to determine the relative concentrations of coal and petroleum carbon in coprocessing products. Selective isotopic fractionation does not appear to occur to a significant extent, although additional work is needed to confirm this preliminary conclusion. Application of the method to the coprocessing of Wyodak and Illinois 6 coals with a Lloydminster resid by the Signal Research/UOP process is shown to yield valid results of use in process interpretation and optimization.

6688 Low severity coprocessing using homogeneous basic nitrogen promoters. Miller, R.L. (Colorado School of Mines, Golden (USA)); Giacomelli, G.F.; Baldwin, R.M. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 154-162 (1988). (CONF-8806312–: Symposium on coal-derived fuels - coprocessing, Toronto (Canada), 5-10 Jun 1988).

In searching for effective coal dissolution promoters to be evaluated at low severity coprocessing conditions, the authors concluded that, based on results from high severity studies, basic nitrogen compounds warranted extensive study. They hypothesized that utilizing basic nitrogen compounds at lower severity would reduce adduction sharply, but that effectiveness towards promoting coal dissolution would remain high. The first low severity coprocessing experiments to test this hypothesis were conducted using Wyodak subbituminous coal and either unhydrotreated or mildly hydrotreated shale oil each containing approximately 1.0 wt % heterocyclic basic nitrogen. Mild hydrotreatment of the shale oil prior to coprocessing greatly improved both liquid yield and THF soluble coal conversion. Yield and nitrogen balance results suggested that significantly less adduction of nitrogen compounds in the shale oil occurred at low severity reaction conditions compared with earlier high severity coal/shale oil coprocessing experiments. The success of these preliminary runs provided the incentive to begin a more fundamental study on the use of basic nitrogen compounds to promote coal dissolution and increase distillate yields at low severity reaction conditions. Initial results from model compound studies are reported in this paper.

6689 Application of first-order single-reaction model for coal devolatilization over a wide range of heating rates. Ko, G.H. (Massachusetts Institute of Technology, Cambridge (USA)); Sanchez, D.M.; Peters, W.A.; Howard, J.B. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 112-119 (1988). (CONF-8806317–: Mathematical simulation of coal conversion processes, Toronto (Canada), 5-10 Jun 1988).

The first-order single-reaction model offers a simple but effective mathematical description of coal devolatilization. Under conditions where the effects of physical transport processes and secondary reactions are relatively small but not negligible, the model approximates the complex chemical decomposition and any transport effects by a single global first-order decomposition reaction occurring uniformly throughout the particle. In more complete devolatilization descriptions that explicitly include mass transfer, the model represents only the chemical decomposition. The model is most useful in applications where minimizing computational effort is important such as in large combustion or gasification models that fully describe fluid mechanism, heat and mass transport, and reaction kinetics; and in comprehensive devolatilization models that explicitly include the complex decomposition and secondary reaction chemistry, and multicomponent mass transfer in a gaseous or liquid phase environment. However, the model has a major weakness in that a different set of rate parameters is required at different heating rates. Thus, for a given set of rate parameters, the applicability of the model is confined to a narrow range of heating rates. This paper presents a novel method to extend the applicability of the first-order single-reaction model over a wide range of heating rates. The two rate parameters in the model, a pre-exponential factor and activation energy, are derived in the form of heating rate dependent functions. The total weight loss data from devolatilization of a Montana lignite over heating rates from ≈0.1 to 10^4 C/s were used to illustrate the derivation procedure, and to test the reliability of this method.

6690 A mechanistic model for axisymmetric cavity growth during underground coal gasification. Britten, J.A. (Lawrence Livermore National Laboratory, CA (USA)); Thorsness, C.B. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 126-137 (1988). DOE Contract W-7405-ENG-48. (CONF-8806317–: Mathematical simulation of coal conversion processes, Toronto (Canada), 5-10 Jun 1988).

A model for cavity growth and gas production during UCG, based on the assumption of cylindrical cavity symmetry and applicable for gasification of shrinking coals when injection low in the coal seam can be maintained, has been developed. The model is highly idealized, but treats includes all important factors impacting cavity growth such as water influx, porous media flow, heterogeneous and homogeneous chemical reactions, radiative and convective heat transfer, and rock mechanics. Model predictions have been shown to agree very well with available field data, and while detailed

produced gas compositions cannot be estimated, it is felt quite adequate to describe in a semiquantitative fashion cavity evolution, energy recovery, aquifer response, and effects of process parameter changes, and therefore is a useful tool for UCG site characterization and module optimization.

6691 Modeling of a high-temperature direct coal gasification process in a two-stream reactor. Hanjalic, K. (Univ. of Sarajevo-Energoinvest (Yugoslavia)); Sijercic, M.; Crowe, C.T.; Wojcicki, S. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 138-144 (1988). (CONF-8806317–: Mathematical simulation of coal conversion processes, Toronto (Canada), 5-10 Jun 1988).

A new scheme for direct gasification of pulverized coal has been analyzed by a mathematical model. Gasification occurs in the annular region of a cylindrical reactor during the cocurrent flow of a steam/coal mixture, with combustion products in the reactor core region serving as an internal heat source. The model incorporates the two equation model for turbulence, mass exchange between phases due to chemical reactions and radiative heat transfer. Detailed calculations are carried out to assess the feasibility of the scheme.

6692 Continuous kinetic lumping for lignite liquefaction. Moore, P.K. (Texas A & M Univ., College Station (USA)); Anthony, R.G. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 157-164 (1988). (CONF-8806317–: Mathematical simulation of coal conversion processes, Toronto (Canada), 5-10 Jun 1988).

The key to an improved coal liquefaction kinetic model is the development of an analytical method capable of separating the reaction products into individual molecular components; The SEC-GC-MS (size exclusion chromatography-gas chromatography-mass spectroscopy) analytical method satisfies this need by providing detailed compositional information, such as the chemical and volatility properties of each component. The tremendous detail provided by the SEC-GC-MS method can then be effectively parameterized using the continuous lumping method, which allows the detailed analytical results to be incorporated into complex kinetic and thermodynamic calculations, such as the equation-of-state VLE calculation described above. Thus, the SEC-GC-MS analytical method and the continuous lumping method, both developed at Texas A&M University, allow the application of advanced theory to the coal liquefaction process.

6693 An equilibrium-thermodynamic analysis of sulfur release and capture in a gasification/combustion environment. Nagarajan, R. (West Virginia Univ., Morgantown (USA)); Khan, M.R.; Pham, H.N.; Anderson, R.J.; Headley, L.C. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 197-207 (1988). (CONF-8806317–: Mathematical simulation of coal conversion processes, Toronto (Canada), 5-10 Jun 1988).

Coal and coal-derived liquids and gases constitute an economically attractive alternative energy source to liquid petroleum fuels. Ongoing research programs at DOE-METC are currently examining the potential of inexpensive production of clean liquid and solid fuels from coal by mild gasification, and of gaseous fuels by countercurrent pressurized fixed-bed gasification. The simultaneous release of gaseous sulfur species (H_2S, COS, SO_2, SO_3) is an inherent environmental limitation to a large-scale practical application of these processes. A computational technique to estimate the release of sulfur from coal and subsequent capture by calcium-based sorbents is presented here, where both processes are assumed to proceed to equilibrium under devolatilization, gasification (reducing), and combustion (oxidizing) conditions. A free-energy minimization computer program (PACKAGE) is used here to simulate local thermochemical equilibria in these reactive atmospheres. Predicted partial pressures of sulfur species are compared with experimental data on sulfur release and sorption, and conclusions are drawn regarding the usefulness and limitations of an equilibrium approach to modeling these processes.

6694 Time-resolved particle temperature and mass loss measurements of a bituminous coal during devolatilization. Fletcher, T.H. (Sandia National Labs., Livermore, CA (USA). Combustion Research Facility). *Combustion and Flame (USA),* 78(2): 223-236 (Nov 1989).

Time-resolved measurements of the rate of devolatilization of high volatile bituminous coal particles in nitrogen at gas temperatures of 1050 and 1250K are presented. Size fractions studied here are 63-75 and 106-125μm in diameter, with particle heating rates approaching 10^4K/s. Particle samples are collected in a helium-quench probe, and a multielement tracer technique is used to determine overall mass loss due to devolatilization. An in situ method is used for simultaneously measuring the size, temperature, and velocity of individual coal particles during pyrolysis. The particle temperature measurement is performed using infrared pyrometry at wavelengths of 1.3 and 2.2μm. The minimum detection threshold for a 100-μm particle in this system is 850K. The measured particle temperature history is combined with the mass loss determinations in order to study overall coal devolatilization rates. Experimentally determined coal devolatilization rates obtained using this facility are compared with published engineering kinetic models.

6695 Desulfurization of coal by photo-oxidation. Mathur, V.K. (Univ. of New Hampshire, Durham (USA)); Murphy, S. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 232-238 (1988). (CONF-8806313–: Sulfur chemistry in coal, Toronto (Canada), 5-10 Jun 1988).

Desulfurization of coal by oxidative methods has been investigated by several workers. These techniques primarily involve selective oxidation of organic sulfur to sulfoxide and sulfones, followed by thermal decomposition of the oxidation product. In this study, photo-oxidation of sulfur in coal is investigated. Finely divided coal samples, suspended in solvent(s), are exposed to radiation using ultraviolet and xenon lamps. The coal samples are next subjected to hydrolysis to remove the oxidized sulfur from the coal matrix. The effect of wave length, light intensity, slurry concentration, and duration of exposure is studied. The maximum desulfurization achieved is about 42%.

6696 Influence of coal type and pyrolysis temperature on sulfur distribution in products during devolatilization. Khan, M.R. (Morgantown Energy Technology Center, WV (USA)). *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 253-264 (1988). (CONF-8806313–: Sulfur chemistry in coal, Toronto (Canada), 5-10 Jun 1988).

During coal devolatilization, the coal sulfur is distributed into solid, liquid, and gaseous products depending on the type and quantity of the coal sulfur and the processing conditions (e.g., temperature, pressure, and heating rate) used. In this study, a series of coals was devolatilized at a relatively low temperature in a fixed-bed reactor in an inert atmosphere. The distribution of sulfur in solid, liquid, and gaseous products was monitored. Influence of peak devolatilization temperature on sulfur distribution in products was determined for a high-volatile bituminous coal (Pittsburgh No.8). The sulfur content of the pyrolysis liquids generated at 500 C correlate well with the total coal sulfur. The total sulfur of the char can be correlated with the pyritic sulfur content of the coal. Total gaseous sulfur content (sum of H_2S and COS) increases with the increase in pyritic or organic sulfur of coal but direct correlations are poor. An increase in pyrolysis temperature increases the total gaseous sulfur yield. Based on sulfur distribution data for about 25 coals, models have been developed to correlate the sulfur yield in products with the total sulfur of the feed col.

6697 Evolution of sulfur gases during coal pyrolysis. Oh, M.S. (Lawrence Livermore National Laboratory, CA (USA)); Burnham, A.K.; Crawford, R.W. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 274-282 (1988). DOE Contract W-7405-ENG-48. (CONF-8806313–: Sulfur chemistry in coal, Toronto (Canada), 5-10 Jun 1988).

The yields and rates of evolution of sulfur gases depend not only on pyrolysis conditions but also on the coal itself. The organic/inorganic forms of sulfur, as well as the secondary reactions of sulfur gases with solids and with other pyrolysis-generated gases, play an important role. Monitoring the time- and temperature-dependent evolution of sulfur-containing gases provides insight into the sulfur chemistry affecting evolution profiles. programmed-temperature studies of sulfur gas evolution often have been limited to H_2S. In some cases, all sulfur gases have been studied collectively by reducing or oxidizing them to H_2S or SO_2. Recently, Calkins studied the evolution of individual sulfur species from a Pyroprobe using

Gas Chromatograph/Mass Spectrometer (GC/MS) and from isothermal flash pyrolysis. Boudou et al. also identified some individual sulfur gases from isothermal pyrolysis using a Curie-point reactor in combination with MS, GC, and GC/MS. In this study, the authors monitored the real-time evolution of sulfur gases during slow-heating pyrolysis via a triple quadrupole mass spectrometer (TQMS). They also monitored the evolution of hydrocarbon gases, water, and carbon oxides. They compared the evolution profiles of sulfur gases and related them to the rank of the coal, the organic and inorganic sources of sulfur in each coal sample, and the evolution of other pyrolysis-generated gases. The authors also studied the extend of secondary reactions by varying the pyrolysis conditions.

6698 **Separation of CO_2 and H_2 mixtures using reactive ion exchange membranes.** Way, J.D. (SRI International, Menlo Park, CA (USA)); Hapke, R.L. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 283-288 (1988). (CONF-8806314–: Separation processes for coal conversion, Toronto (Canada), 5-10 Jun 1988).

Liquids and rubbery polymers are good candidate membrane materials for the separation of CO_2 from mixtures with H_2 because the solubility selectivity controls the separation that can be obtained. Facilitated transport IEMs containing monopositive ethylene diamine counterions have been shown to be selectively permeable to CO_2 over H_2. Transport measurements are conducted to determine the influence of feed gas mixture composition, pressure, temperature, and solvent on the CO_2 H_2 permeabilities and separation factor.

6699 **Removal of hydrogen chloride from high temperature coal gases.** Krishnan, G.N. (SRI International, Menlo Park, CA (USA)); Wood, B.J.; Tong, G.T. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 292-299 (1988). (CONF-8806314–: Separation processes for coal conversion, Toronto (Canada), 5-10 Jun 1988).

Currently available processes for removing HCl vapor operate at relatively low temperatures (T < 300 C) and thus they are not suitable for use with hot coal gases (T > 500C). This paper presents the results of a laboratory-scale evaluation conducted at SRI International to determine the effectiveness of naturally occurring minerals and commercially available sorbents to remove HCl vapor from simulated coal gas streams at temperatures from 550 to 650 C. The thermodynamic stability and the volatility of the solid chloride products were the major criteria in selecting the nature of the sorbent. Alkaline earth chlorides, generally, are less volatile than alkali metal chlorides and transition metal chlorides. However, the calculated equilibrium partial pressure of HCl over alkali metal chlorides were calculated to be lower than those over alkaline earth compounds. In considering these two factors, along with availability in a natural form, sodium carbonate based sorbents were judged to be superior to other compounds.

6700 **Pyrolysis of coals loaded with polycyclic aromatic hydrocarbons.** Malhotra, R. (SRI International, Menlo Park, CA (USA)); St. John, G.; Tse, D.S.; McMillen, D.F. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 257-261 (1988). (CONF-8806318–: Low temperature pyrolysis, Toronto (Canada), 5-10 Jun 1988).

The relative simplicity of pyrolysis offers significant advantages as a coal conversion approach. However, char yields are typically high and volatile products are generally distributed between low value light hydrocarbons and tars that can be very difficult to upgrade. Consequently, the pyrolysis of coals under conditions that would produce larger yields of condensible and readily upgradable hydrocarbons is clearly a desirable goal, and the literature contains many examples of approaches to augmenting pyrolysis yields. For this reason, it is desirable that additional efforts be conducted as much as possible in light of what is known about the mechanism of volatiles production. In order that the loading with aromatics be an effective pretreatment, the reaction conditions must allow for an opportunity for the aromatics to react with the coal before they are simply devolatilized. Liquefaction and coking provide ample opportunity for reactions between the added aromatics and the coal while pyrolysis conditions generally do not favor such interactions. In this paper the authors report their efforts at determining the range of conditions under which loading of coals with PCAH may result in beneficial effects during pyrolysis.

6701 **Chemical characteristics of tars produced in a novel low severity, entrained flow reactor.** Freihaut, J.D. (United Technologies Research Center, East Hartford, CT (USA)); Proscia, W.M.; Seery, D.J. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 262-282 (1988). (CONF-8806318–: Low temperature pyrolysis, Toronto (Canada), 5-10 Jun 1988).

This communication reports the utilization of a novel entrained flow reactor and product isolation system. In contrast to the operation of most entrained flow reactors, no attempt is made to match the entrainment gas and wall temperatures. Entrainment gas temperatures are purposely kept below wall temperatures to minimize extra-particle gas phase reactions of tars. To obtain char-free tar samples, an aerosol phase separation system is employed to isolate a significant fraction of entrained tar species from the char mass. Both the char particle and aerosol arms of the product separation system contain serially staged particulate separation systems followed by porous metal final filters that collect pure tar species.

6702 **Pyrolysis of the Argonne premium coals under slow heating conditions.** Serio, M.A. (Advanced Fuel Research, Inc., East Hartford, CT (USA)); Solomon, P.R.; Carangelo, R.M. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 295-309 (1988). (CONF-8806318–: Low temperature pyrolysis, Toronto (Canada), 5-10 Jun 1988).

A recent general model of coal pyrolysis proposed by the authors' research group has as one of its assumptions that the kinetics of primary product evolution are rank-insensitive. This assumption was tested by a thorough examination of data from experiments where only coal type was varied as well as data from similar experiments in the literature. The conclusion was that, with few exceptions, the kinetic rate constants show little variation with rank. However, this conclusion remains controversial. The Argonne premium samples provide an opportunity to further test this assumption with a set of coals that was designed to cover a wide range of coal types. A slow, constant heating rate experiment was used, which is the most sensitive to rate variations. A second controversial area is the importance of heating rate on the volatile product yield and distribution. Evidence has been presented which suggests no intrinsic effect of heating rate on pyrolysis yields and other studies have indicated the converse to be true. However, often these studies have been done under sufficiently different experimental conditions that direct comparisons are difficult. Work has indicated a role for heating rate on tar yields for bituminous coals and on tar molecular weight distributions for lignites. The authors plan to extend this work to the Argonne coals in order to better establish these trends. The current paper is concerned primarily with pyrolysis of the Argonne coals under slow heating conditions in a unique TG-FTIR instrument developed in this laboratory. Results from slow heating rate pyrolysis into a FIMS apparatus are also presented.

6703 **Removal of H_2S from coal-derived gases.** Lynn, S. (Univ. of California, Berkeley (USA)); Hix, R.M.; Neumann, D.W.; Sciamanna, S.F.; Stevens, C.A. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 300-305 (1988). DOE Contract AC03-76SF00098. (CONF-8806314–: Separation processes for coal conversion, Toronto (Canada), 5-10 Jun 1988).

When coal is gasified most of the sulfur is converted to H_2S and must be removed before the gas can be used either as a fuel or as synthesis gas. The UCB Sulfur Recovery Process (UCBSRP) is being developed as a general method for removing H_2S from gases. The H_2S is absorbed in a polyglycol ether, then reacted in the liquid phase with SO_2 to form marketable elemental sulfur and water. The process allows high specificity and flexibility; H_2S can be reduced to the part-per-million level or below in the presence of CO_2 and the other components of gasified coal. The CO_2 may be left in the original gas stream or it may be co-absorbed and recovered as a separate, sulfur-free product. The process thus has application both to syngas and hydrogen production from O_2-blown gasifiers and to power production using an air-blown gasifier. This paper describes process configurations, gas and sulfur solubilities in process solvents, reaction kinetics, corrosion studies, sulfur crystallization, gas absorption with chemical reaction, and the work required for proof-of-concept.

6704 Sorbent-based recovery of sulfur from regeneration tail gases. Gangwal, S.K. (Research Triangle Institute, Research Triangle Park, NC (USA)); Harkins, S.M.; Dorchak, T.P. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 306-309 (1988). (CONF-8806314--: Separation processes for coal conversion, Toronto (Canada), 5-10 Jun 1988).

This paper discusses the results of experimental/theoretical research on two novel process concepts for elemental sulfur production from regeneration tail gases. Both concepts utilize a highly efficient sodium/aluminum (Na/Al) based SO_2 sorbent at elevated temperatures (800 to 1,000 K) and pressures (1 to 3 MPa). One concept involves sulfation of the Na/Al sorbent with the tail gas followed by regeneration with reducing gas to produce a suitable Claus plant feed. The other concept aims for single step sulfur production by reacting the tail gas with a small quantity of raw coal gasifier product gases over the sorbent.

6705 Separation of gas mixtures by transition-metal complexes. Lilga, M.A. (Battelle, Pacific Northwest Laboratory, Richland, WA (USA)); Hallen, R.T.; Nelson, D.A. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 310-313 (1988). DOE Contract AC06-76RL01830. (CONF-8806314--: Separation processes for coal conversion, Toronto (Canada), 5-10 Jun 1988).

The selective separation or purification of gases, especially hydrogen and CO, is highly desirable in processes utilizing product gas from coal gasification. However, gas separation is a difficult and energy intensive process. The Pacific Northwest Laboratory (PNL) is examining transition-metal complexes as selective agents for the separation of syngas components from gas mixtures. Transition-metal complexes are known which react reversibly with gases such as H_2, CO, O_2, and CO_2. This reversible binding can be used to transfer the gas from a region of high partial pressure to a region of lower partial pressure. The selectivity of transfer is determined primarily by the selectivity of the metal in binding a specific gas. The nature of the ligands surrounding the metal has a large influence on the selectivity and reversibility and the authors have successfully used ligand modification to prepare complexes that have improved properties for H_2 or CO binding. Applications of metal complexes to gas separation and two specific examples of metal complexes under study are discussed.

6706 The removal of impurities from hot coal-derived gas by filtration. Grindley, T. (Morgantown Energy Technology Center, WV (USA)); Logan, R.G. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 315-328 (1988). (CONF-8806314--: Separation processes for coal conversion, Toronto (Canada), 5-10 Jun 1988).

At the Morgantown Energy Technology Center (METC) of the U.S. Department of Energy, an effort is underway to clean hot coal-derived gas to a sufficient purity for combustion in heat engines and other applications. Experiments were conducted in which the hot product gas, raw and desulfurized, from a fluid-bed coal gasifier was filtered at temperatures up to 1,600 F, pressures up to 250 psig, and flow rates up to 2,500 scfh. Particulate and condensate samples were collected at the inlet and outlet of the filters and analyzed for 10 metals which are common constituents of coal ash. The results were used to determine how filtration of particles from a gas stream at high temperatures affected metal concentrations in the gas. In general, the removal efficiency for the metals correlated with the particulate removal efficiency.

6707 Studies of catalytic upgrading of low-severity liquefaction products from low-rank coals. Olson, E.S. (Univ. of North Dakota Energy and Mineral Research Center, Grand Forks (USA)); Diehl, J.W.; Sharma, R. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 332-338 (1988). (CONF-8806314--: Separation processes for coal conversion, Toronto (Canada), 5-10 Jun 1988).

This paper is concerned with the catalytic hydrotreatment of a low-severity product obtained from the liquefaction of a Wyodak subbituminous coal in tetralin solvent at 384 C (1 hour) in carbon monoxide plus hydrogen sulfide. The low-severity product was separated into two fractions, a methylene chloride soluble fraction and methylene chloride insoluble fraction. The results from second stage liquefaction of the methylene chloride soluble fraction under various conditions are reported here. This fraction comprised the major portion of the low-severity product. The second stage reaction used the same solvent as the first stage. This solvent was chosen because it does not contain oxygen and is a simple system whose products, naphthalene, decalin, methylindan, butyl benzene and dimers, can be easily distinguished in the reaction products. Two reaction temperatures (425 C and 450 C) were used in the high severity treatments. Runs for one or two hours were conducted. Hydrogen pressure was another variable during these investigations, although all reactions contained the same amount of the sulfided Co-Moly catalyst.

6708 Performance of hydrous titanium oxide-supported catalysts in coal-liquids upgrading. Cillo, D.L. (Department of Energy, Pittsburgh, PA (USA)); Smith, D.N.; Ruether, J.A.; Stephens, H.P.; Dosch, R.G. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 348-354 (1988). (CONF-8806314--: Separation processes for coal conversion, Toronto (Canada), 5-10 Jun 1988).

Experimental tests were performed in a continuous-flow hydrotreating unit at Pittsburgh Energy Technology Center to evaluate the performance of hydrous titanium oxide-supported (HTO) catalysts as hydrotreating catalysts for use in two-stage coal liquefaction. Catalysts containing either a combination of Co, Ni, and Mo as the active metal components or Pd as the active metal component were tested with representative hydrotreater feed stocks from the Wilsonville Advanced Coal Liquefaction Research and Development Facility. Catalyst performance evaluation was based on desulfurization and denitrogenation activity, the conversion of cyclohexane-insoluble material, and hydrogenation activity, during 100-hour reactor runs. Results indicated that the HTO catalysts were comparable to a commercial Ni/Mo-alumina supported catalyst in the areas evaluated.

6709 Process options for extinction recycle conversion of heavy oils in catalytic two stage liquefaction. Comolli, A.G. (Hydrocarbon Research, Inc., Lawrenceville, NJ (USA)); Johanson, E.S.; McLean, J.B.; Smith, T.O. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 364-375 (1988). (CONF-8806314--: Separation processes for coal conversion, Toronto (Canada), 5-10 Jun 1988).

Hydrocarbon Research, Inc. (HRI) is developing a Catalytic Two-Stage Liquefaction (CTSL) Process which converts coal to distillate liquid products. A particularly attractive feature of the process that has been demonstrated recently using two bituminous coal feedstocks (Illinois No. 6 and Ohio No. 5/6 coals) is the capability to achieve extinction conversion of heavy oil products (heavy vacuum distillate and soluble residuum oil) through integration of coal cleaning, product solids separation, and selective recycle. Yields of distillate oils of up to five barrels per M.A.F. ton of coal have been achieved. Elimination of heavy oils of boiling points above 700-750 F greatly simplifies downstream processing requirements. Several process configuration options and the resulting yield distributions are discussed.

6710 Activity and selectivity of molybdenum catalysts in coal liquefaction reactions. Curtis, C.W. (Auburn Univ., AL (USA)); Pellegrino, J.L. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 376-383 (1988). (CONF-8806314--: Separation processes for coal conversion, Toronto (Canada), 5-10 Jun 1988).

The purpose of this work is to evaluate how effectively three different molybdenum catalysts promote reactions involving heteroatom removal and cleavage of alkyl bridge hydrodeoxygenation (HDO), hydrodesulfurization (HDS), hydrodenitrogenation (HDN) and hydrocracking (HYC). Both model and coal liquefaction reactions were performed to test the activity and selectivity of three different molybdenum catalysts. The three catalysts used were molybdenum naphthenate, molybdenum supported on gamma alumina (Mo/Al_2O_3) and precipitated, poorly crystalline molybdenum disulfide (MoS_2). The model compounds, chosen to mimic coal structure, on which the effectiveness of the catalysts for the model reactions was tested were: 1-methylnaphthalene, representing aromatic hydrocarbons, for hydrogenation; 1-naphthol, representing oxygen containing compounds, for deoxygenation; benzothiophene, representing sulfur containing compounds, for desulfurization;

indole, representing nitrogen containing compounds, for denitrogenation; and bibenzyl, representing alkyl bridging structures, for hydrocracking. Catalytic reactions of combinations of reactants were performed to simulate a complex coal matrix. Thermal and catalytic coal liquefaction reactions were performed using Illinois No. 6 coal with anthracene as a solvent. The efficacy of the catalysts was determined by comparing the product and compound class fractions obtained from the liquefaction reactions.

6711 **Origins and reactions of alkyls and alkanes in direct coal liquefaction.** Moroni, E.C. (Department of Energy, Washington, DC (USA)). *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 384-386 (1988). (CONF-8806314–: Separation processes for coal conversion, Toronto (Canada), 5-10 Jun 1988).

While the analytical determination of alkyls presence in the products of coal conversion and the speculation of their original status in the coal matrix have been extensively studied, their roles in the various reactions occurring in coal liquefaction have not received adequate attention by the research community. For a more fundamental approach in coal liquefaction there is an opportunity to study the reactions occurring at the low temperature ranges, say 250-380 C, for each of the reactive components, or each group of components present in coal or formed in the initial stages of liquefaction, which can be related to the most significant beneficial effects observed in the staged temperature experiments. By increasing the reaction temperature to above 380-400 C, the researcher must be aware that he or she is approaching the threshold separating the predominance of hydrogenation reactions of aromatic compounds at the lower temperatures from those of dehydrogenation of hydroaromatic compounds which occurs at the higher temperatures. This paper intends to present some of the reactions involving alkyl groups as well as formation of alkanes, which might have important roles in coal liquefaction. The paper has the additional objective to stimulate the research community to undertake a more systematic research approach in liquefaction which ought to separate the many reactions occurring at the lower temperature range from the subsequent reactions occurring at the higher temperatures. The latter are profoundly affected by the way the former are carried out.

6712 **Crosslinking reactions in coal pyrolysis.** Deshpande, G.V. (Advanced Fuel Research, Inc., East Hartford, CT (USA)); Solomon, P.R.; Serio, M.A. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 310-321 (1988). (CONF-8806318–: Low temperature pyrolysis, Toronto (Canada), 5-10 Jun 1988).

During coal pyrolysis, the break up of the coal macromolecular network is controlled by the relative rates of bond breaking, crosslinking and mass transport. Crosslinking reactions are important because the ultimate tar yield and tar molecular weight distribution are dependent on the extent of these reactions. Crosslinking, as measured by solvent swelling experiments, is observed to be rank dependent, with lignites crosslinking at lower temperatures than bituminous coals. In a recent study of crosslinking, Suubert et al. observed that the crosslinking rate appeared to correlate with the evolution of CO_2. This correlation was confirmed by Solomon et al. It appears that crosslinking may be related to the decomposition of carboxyl groups (whose concentration is rank dependent) to form CO_2. Recent research has also demonstrated that substantial reductions in the crosslinking reactions can be achieved by ultra rapid heating. The high heating rate conditions for lignites produce melting and swelling of char, higher yields of soluble products, and product molecular weight distributions previously seen only for melting, easily soluble coals.

6713 **A chemical model of coal devolatilization using percolation lattice statistics.** Grant, D.M. (Univ. of Utah, Salt Lake City (USA)); Pugmire, R.J.; Fletcher, T.H.; Kerstein, A.R. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 322-332 (1988). (CONF-8806318–: Low temperature pyrolysis, Toronto (Canada), 5-10 Jun 1988).

The authors have developed a model for coal devolatilization that incorporates the diversity of coal structure in such a way that the analytical data obtained from solid state NMR provides the initial input data. Using an experimentally determined kinetic rate parameters, it is possible to fit the gas, tar and char production of a lignite and high volatile bituminous coal. The authors have employed percolation theory to provide analytical expressions for the lattice statistics required in devolatilization modeling. The percolation theory allows one to avoid the more time consuming Monte Carlo technique with no loss of generality or important statistical features. Percolation theory analytically describes the size distribution of finite clusters of sites joined by intact bridges but isolated from all remaining sites by broken bridges. The theory specifies a critical bridge population, depending only on the site coordination number, above which infinite arrays will coexist with clusters of finite size. It is a simple matter to adapt the structural features of percolation theory to both the tar and gas obtained in coal pyrolysis. The infinite arrays of percolation theory are interpreted as the macroscopic lattice of unreacted coal and/or char while the relatively small tar molecules may be identified with the fine clusters of percolation theory. The details of the model are discussed together with the results obtained in modeling devolatilization behavior of coals of various ranks.

6714 **The comparison of a lignite char, subbituminous coal char, and a bituminous coal char used in the reaction with steam to produce hydrogen.** Timpe, R.C. (Univ. of North Dakota Energy and Minerals Research Center, Grand Forks (USA)); Sears, R.E. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 359-367 (1988). (CONF-8806136–: American Chemical Society Division of Fuel Chemistry meeting, Toronto (Canada), 5-10 Jun 1988).

The use of coal as carbon source in the char-steam reaction to produce hydrogen gas over the temperature range 700-800 C (973-1,073 K) at atmospheric pressure has been studied in detail. Velva lignite has properties which give its char superior reactivity over those of the other coals tested. Catalysis with alkali carbonates enhanced the reactivity of Velva char substantially, whereas demineralization reduced the reactivity to a relatively constant value over the temperature range studied by removing inorganic material and altering the surface characteristics of the coal. Char produced from a Wyodak subbituminous coal and River King bituminous coal were much less reactive than Velva in the absence of catalyst but responded positively to the addition of alkali carbonates. Upon demineralization, these coals also showed reduced reactivity and altered surface features. This paper discusses the results of the experiments in terms of the reactivity data, SEM photos and elemental mapping, organic properties as determined from ^{13}C NMR and ESCA spectroscopy, and inorganic content of the substrates.

0105 Products and By-Products

Refer also to citation(s) 6590, 6591

0106 Properties and Composition

Refer also to citation(s) 6500, 6504, 6556, 6558, 6585, 6586, 6587, 6588, 6589, 6590, 6591, 6619, 6683, 6686, 6691, 6695, 6769, 6772, 6788, 6797, 6815, 7862

6715 (ANL/PCSP–89/1) **Users handbook for the Argonne Premium Coal Sample Program.** Vorres, K.S. Argonne National Lab., IL (USA). Oct 1989. 68p. Sponsored by U.S. DOE Energy Research. DOE Contract W-31109-ENG-38. Order Number DE90004991. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This Users Handbook is intended to provide the recipients of Argonne Premium Coal Samples with a set of useful information to enhance the value of the samples and permit greater opportunities to compare their work with that of others, and to aid in correlations that can improve the value to all users. It is hoped that this document will foster a spirit of cooperation and collaboration such that the field of basic coal chemistry may be a more efficient and rewarding endeavor for all who participate. The different sections are intended to stand alone to avoid an occasional need to leaf back-and-forth to find particular data. For this reason some of the information may be found in several places. The handbook is also intended to be a dynamic document, constantly subject to change through additions and improvements. Please feel free to write to the editor with your comments and suggestions. 111 refs.

6716 (ARC–CE-02437, pp. 5) **Viscosity of coal-bitumen and coal-anthracene oil slurries.** Ozum, B. (Alberta Research Council, Edmonton, AB (Canada)); Stefurak, G.R.; Plessis du, M.P. Alberta Research Council, Edmonton, AB (Canada). [1982]. (CE–02437). In *Alberta Research Council [research reports].* Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

The viscosity of coal-anthrancene oil and coal-bitumen slurries was measured at coal concentrations up to 50 wt%. A two-parameter non-Newtonian model with zero yield stress was used to interpret the data. The apparent activation energy of viscosity was determined from the temperature and apparent viscosity data. The paper also describes the pipeline test apparatus being constructed for rheology and heat transfer investigations of coal-oil slurries at high temperatures (450C) and high pressures (28 MPa).

6717 (CMRC–8901, pp. 59-74) **Relationship between geologic structure, coal properties and coal liquefaction.** Fujii, Keizo (Geological Survey of Japan, Tsukuba, Japan). Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Results of a geological survey in the western Canada are reported on the geological depositional environment of coal mines, the distribution of coal fields, and the correlation between coal properties and oil yields. The western Canada is geologically divided into the North American Craton in the east, and the Cordillera orogenic zone in the west. Coal in the former distributes ranging from the Alberta plain to the foot of the Rockies, and is mainly classified into that of the Cretaceous period. Since the embedded depth of beds ranging from the Mesozoic era to the Tertiary period increases toward the west from the east with increase in its thickness, the coal rank changes regularly from peat to bituminous coal with increase in bed thickness accompanying the large reserve of coal with a steady property and less ash. In particular, sub-bituminous coal superior in a liquefaction property exists under the Alberta plain. Coal in the Cordillera orogenic zone is unsuitable for liquefaction because of its unsteady property, more ash and less reserve. 8 refs., 13 figs., 4 tabs.

6718 (DOE/PC/89780–T1) **[Basic properties of coals and other solids]: Quarterly report No. 1.** Duke Univ., Durham, NC (USA). Dept. of Chemistry. [1989]. 12p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FG22-89PC89780. Order Number DE90004075. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The project is now fully operational and results are reported herein from initial studies of heats of adsorption of seven acidic materials on Carbopack F carbon as a prototype non-basic, non-acidic solid as a reference point for our subsequent investigation of adsorption of acids on basic solids and various coals. Heats of interaction between a series of substituted aromatic sulphonic acids are also reported for their interaction with polyvinylpyridine as a solid base and monomeric pyridine as a solute in acetonitrile. 6 refs., 4 figs., 3 tabs.

6719 (ECN–89-154) **Coal mineral analysis 'Round Robin'.** Vleeskens, J.M.; Hamburg, G.;. Netherlands Energy Research Foundation, Petten (Netherlands). Oct 1989. 25p. Available from Netherlands Energy Research Foundation ECN, P.O. Box 1, 1755 ZGPetten, Netherlands.

An energy dispersive X-ray system combined with a scanning electronmicroscope is a useful tool to perform coal mineral analysis. A usefulimage analysis programme was developed by workers at US Steel incooperation with Tracor Northern. This coal mineral analysis programme(CMA) is designed to classify a great number of individual particles incoal grains, with respect to their size and chemical composition. Thechemical classification is based on the relative X-ray intensities ofeleven elements. The programme output includes size distribution,weight distribution and average chemical composition for 27 classes ofminerals. Because of the small number of laboratories employing CMA, nointerlaboratory check of results has been performed so far. Consideringthe economical impact of mineral composition on coal processingtechnologies, a reproducibility check seemed to be highly appropriate.This is a summary report of an interlaboratory test in which 6laboratories participated. 1 fig., 2 refs., 15 tabs., 1 app.

6720 (ETDE-mf–0732415) **Development of an experimental facility for simulating rock pressures up to 200 MPa and studies on the changes in the structural characteristics of coal drill cores under pressure.** Anders, S. Technische Univ. Clausthal, Clausthal-Zellerfeld (Germany, F.R.). Fakultaet fuer Bergbau, Huettenwesen und Maschinenwesen. 11 Aug 1987. 155p. (In German). Order Number DE90732415. Available from NTIS (US Sales Only), PC A08/MF A01.

The effect of mechanical pressure on the structure of unloaded coal is to be determined. In the framework of this study, a facility is to be developed which allows the simulation of underground pressures in the laboratory, thus creating the preconditions for a still better approximation of the measuring results from laboratories to the conditions underground. In this context it has to be considered that a practice-related load of the material used shall be possible, i.e. it shall be possible to simulate isotropic as well as anisotropic states of stress in dependence of definable loading rates. The highest possible pressure should amount to 200 MPa. For further examinations measurements of temperature effects and permeabilities under rock pressure should be possible. In addition to the determination of mechanical factors of influence under pressure load and relief, such as compression behaviour and energy storage capacity, an appropriate analysis programme must be prepared for recording the changes of structure under compression loading. This is divided into the petrographic methods which describe the visual perceivable structure on the one hand and the physico-chemical examinations giving indirect information on the inner structure of the coal on the other hand. Furthermore, the functioning of the installation is to be tested by way of orientating experiments and the information value of the prepared analysis programme is to be examined. Due to the complexity of the tasks, the pressure load on cylindrical coal samples is to be applied exclusively from axial direction. (orig./HS).

6721 (FSJ–8901, pp. 276-279) **Oxidation reaction of Miike Coal studied by diffuse reflectance FT-IR spectroscopy.** Yamada, Osamu (National Research Inst. for Pollution and Resources, Tsukuba, Japan); Kaiho, Mamoru; Makino, Mitsunori; Kobayashi, Mitsuo; Yamashita, Yasumasa. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Miike coal was oxidized in a airtight heating room in a diffuse reflectance unit of FT-IR spectrometer and in-situ measurement was carried out to investigate the structure change of the coal by oxidation. Absorbance gain at 1700/cm is caused by the generation of carboxyl group, but the peak is wide, so that the situations are divergent. The absorbance gain of 1546/cm is caused by the generation of COO^- and that of 3400/cm is caused by the generation of OH radical. The effect of oxidation on caking property and swelling property is thought by the generation of ester group. Generation of a large amount of H_2O is caused by the hydrogen extraction from aliphatic compounds and then CO and CO_2 are generated by decarbonylation and decarboxylation. The absorption of carbonyl and OH increased along with the elongation of reaction time. The absorbance zone of aliphatic compounds increased but this may be caused by the generation of hydroperoxide through oxygen attack at the side chain on α carbon location and by the observation of side chain of an aliphatic compound generated by being cut at the location. This behavior of aliphatic hydrocarbons is thought to affect on the breakdown of caking property, etc. 7 refs., 3 figs.

6722 (FSJ–8901, pp. 280-283) **Studies on micro elementary analysis technique of coal and coke.** Inoue, Keizo (Sumitomo Metal Industries Ltd., Osaka, Japan); Nishioka, Kunihiko. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Accuracy of micro elementary analysis to coal and coke was studied. Six kinds of coal of different carbonization degree were used for samples which were prepared by JIS method. ASTM D346 standard sample was used for coke sample. The semi-automatic equipment uses pure oxygen combustion, and analyzing time is 15

minutes. Weighing error can be neglected because the error is 0.02-0.03% for the 1-3mg sample amount by using a micro electronic balance. The detectable error exceeds the JIS accuracy if 0.5mg for C and H, and 1mg for N are sampled. Sample must be ground to average grain size of 40-50μm or less to satisfy the JIS accuracy. It is desirable to have 2mg or more sample for vibrating mill grinding. But vibrating mill tends to oxidize sample, grinding with an agate mortar by adding ethanol is preferable. Accuracy equal to or more than that by JIS can be obtained if 2mg or more sample is taken and ground to 40-50μm grain size. But this method resulted higher value for N in coke by 0.4% than that by the semi-micro Kjeldahl method owing to the loss of volatile matter and incomplete decomposition. 2 refs., 5 figs., 3 tabs.

6723 (FSJ–8902, pp. 230-233) **Systematic investigation of reaction parameters on nonreductive C-alkylation reactions.** Miyake, Mikio (Osaka Univ., Faculty of Engineering, Osaka, Japan); Stock, L.M. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

PSOC-1197 coal, bituminous coal of high rank, was used as a sample and its parameters on nonreductive C-alkylation reaction were examined systematically. The kind and the concentration of a base in the anion treatment and the kind of an alkylation agent in the alkylation treatment were varied to prepare the alkylated coal. And its solubility in Py and solid state NMR spectra were measured. The introduction of long-chain alkylation group was found to be an important factor because the solubility in Py increased rapidly with an increase in the chain length of alkyl iodide(methyl-octyl) which was used as an alkylation agent. Moreover, the solid state NMR spectra of alkylated products prepared with original coal and methyl iodide-^{13}C were compared and reacted using bases with different pK/subA/. As a result, it was suggested that it was possible for C-H bond at the benzil position which linked the aromatic nucleus to contribute as an important reaction site for PSOC-1197 coal. 7 refs., 2 figs., 4 tabs.

6724 (FSJ–8902, pp. 234-237) **Analysis of chemical structure of products obtained by various reductive alkylation methods.** Kurio, Takuya (Osaka Univ., Faculty of Engineering, Osaka, Japan); Miyake, Mikio; Nomura, Masakatsu. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

The RF method and the US method are the improved methods for coal alkylation which has once proposed by Sternberg et al. Both methods were examined using Yubari coal, and their characteristics were compared through the analysis of chemical structure of alkylated products. When ethyl iodide was used as an alkylation agent, ethylation coal prepared by the US method introduced more ethyl groups than by the RF method. Similarly, H%, H/C value, and yield of n-hexane soluble(HS) through the US method were higher than those through the RF method. Consequently, the US method was shown to be more effective for alkylation. The analysis on 600MHz ^{7}H-NMR spectrum of HS and the dealkylation reaction with increased temperature were studied in both methods. As a result, reductive alkylation proceeded as a main reaction in both methods, but it was indicated that the rate of non-reductive alkylation progress was higher in the US method. In the other experiment in which several model compounds were used, some kind of results as above-mentioned was recognized in each of RF and US methods. Moreover, it was found that the US method had more ability to cleave the C-O or C-C bond. 6 refs., 3 figs., 2 tabs.

6725 (FSJ–8902, pp. 238-241) **Origin of long alkyl-chain aromatic compounds in coal (2). Initial diagenetic reaction of lignin with alcohol or fatty acid.** Dong, Ji-Zhou (Hokkaido Univ., Faculty of Engineering, Sapporo, Japan); Ouchi, Koji. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

There is a theory that long alkyl-chain aromatic compounds existing in great quantities in coal have been produced in the reaction of lignin, which consists the xylem of plants, with alcohol or fatty acid. In order to sustain this idea, the reaction of lignin with alcohol was tested. Lignin and alcohol(C_{14}) were put into the autoclave together with activated clay to react. Then, the reacted products were hydrogenated with a catalyst, and benzene soluble fraction(lignin oil B) was obtained. Moreover, lignin was hydrogenated directly and benzene soluble fraction(lignin oil A) was gained. Gas chromatograms of both lignin oil A and B were compared, and each peak was identified. As a result, many peaks which were not in B were found in A. These were C_{14}-phenol, C_{14}-indanol, and others, and it was assumed that they were produced in the reaction with alcohol. This result suggested the rightness of the above theory on the origin of long alkyl-chain aromatic compounds in coal. 4 refs., 2 figs., 2 tabs.

6726 (FSJ–8902, pp. 246-249) **Relationship between coal properties and maceral at Fushun and Fuxin coal mines, China.** Fujii, Keizo (Geological Survey of Japan, Tsukuba, Japan); Suzuki, Yuichiro; Li, Sitian; Wu, Chonglong. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Characteristics of major coal seams at Fushun and Fuxin coal mines were described from the viewpoint of coal maceral, calorific value, volatile constituents, and H/C atom ratio. Variations of these factors along vertical direction in coal seams were also explained in relation to the circumstances(oxidation or reduction) of coal generation. In addition to these data, Japanese coal and Pennsylvanian coals were included, and they were studied on the relation between volatile matter content and calorific value, and between H/C and O/C atom ratio. By analyzing the diagram showing the former relation, it was presumed that, in general, coal with less volatile matter content was generated under the oxidizing circumstances. Fushun coal, as well as Fuxin coal, is mainly composed of vitrinite group macerals, however, the former characterized by degradinite, but the latter contains no degradinite. Supposing the environment of coal generation, Fushun coal and Fuxin coal, as well as coal from palaeogene stratum in Japan, would have been generated under the more reductive circumstances than that of pennsylvanian coal. 2 refs., 4 figs.

6727 (FSJ–8902, pp. 250-253) **Biological marker of coal for analysis of coal property and generation.** Suzuki, Yuichiro (Geological Survey of Japan, Tsukuba, Japan); Fujii, Keizo; Kaneko, Nobuyuki; Sakata, Susumu. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

A biological marker was analyzed on coal samples obtained from many coal seams of seven major mines in Hokkaido in Japan and Fushun coal field in China. Observation was concentrated on sterane and triterpane(hopane) which were admitted as important biological markers. Using the gas chromatography-mass spectroscopy apparatus, their mass fragmentogram was measured and each of their peak was identified. The stereoisomers ratio(S/S+R) on the side chains of bishomohopane and stigmastane(C_{29} sterane), which were admitted as the excellent indices of coalification, were investigated, and their correlations with vitrinite refrectance R_o were studied. Observing the coal from West Open Pit of Fushun coal field, the stereoisomers ratio of sterane was almost constant, in contrast to the remarkably dispersed R_o. Distribution of C_{27}, C_{28}, and C_{29} steranes was approximately constant in all kinds of coal tested, and fell into the domain corresponding to the higher land plants. From the result of the study, it was shown that the biological marker could be a stable index for the rank of coalfication. 6 refs., 6 figs.

6728 (FSJ–8902, pp. 254-257) **Measurement of carbon aromaticity in various coals by solid state ^{13}C-NMR.** Moritake, Mitsuru (Osaka Gas Co., Ltd., Osaka, Japan); Matsumoto, Masaru; Nakamura, Takuji. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Carbon aromaticity in various types of coal such as brown coal, bituminous coal, and anthracite was studied using high resolution solid state ^{13}C-NMR apparatus. Aromatic carbon ratio (f_a), dry and ash-free conversion for carbon content ($C_{daf)}$,and$_H$C and O/C atom ratios were determined, and then, correlations among these factors were investigated. The CP/MAS method and the CP/MAS/DD

method were used to obtain an NMR spectrum. Concerning the f_a-C_{daf} correlation, f_a increased in proportion to the increase of C_{daf} when the range of C_{daf} was under 70% or over 80%. f_a however, increased scarcely and showed scattered values when C_{daf} was in the intermediate range between 70% and 80%. Firm correlation was observed between f_a and H/C, as well as between f_a and O/C. Moreover, distribution of carbon over various types of radical and the protonated aromatic carbon ratio were also studied. It was suggested that these factors could be indices in selecting the type of coal suitable for hydrocracking and in estimating the number of substituent. 7 refs., 6 figs., 1 tab.

6729 (FSJ–8902, pp. 258-261) **Characterization of various coals by high-resolution solid-state ^{13}C-NMR.** Hayamizu, Kikuko (National Chemical Laboratory for Industry, Tsukuba, Japan); Yanagisawa, Masaru; Yumura, Motoo; Kuriki, Yasunori; Oshima, Satoshi; Kawamura, Mitsutaka. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Fraction of aromatic carbon (f_a) required from solid-state ^{13}C-NMR is an important index for evaluating coal property. In obtaining NMR spectrum, however, how to set the cross polarization time(CP time) is an important factor. In this report, ^{13}C-NMR spectra were observed on four types of coal including Hongay coal(anthracite) with various CP time, and changes in the areal intensity of aromatic and aliphatic carbons were compared. The CP time dependency by the areal intensity of aromatic carbon differed appreciably due to coal types. By Hongay coal with high degree of carbonization, the areal intensity of aromatic carbon became highest at the shortest CP time, and decreased steeply as the CP time became longer. These results suggest that the analysis of the relation between the CP time and the areal intensity of aromatic or aliphatic carbon is effective to examine the structural characteristics of coal. The optimum CP time estimated from the experimental results was as follows: 0.9ms for Taiheiyo coal (f_a=0.48) and 0.6ms for Hongay coal (f_a=0.86). Consequently, it was found that the optimum CP time depended upon the carbonization degree of coal. 5 figs.

6730 (FSJ–8902, pp. 262-264) **Chemical structure of the extracts from the extraction with carbon disulfide-N-methyl-2-pyrrolidone mixture.** Iino, Masashi (Tohoku Univ., Sendai, Japan); Takanohashi, Toshimasa; Obara, Satoshi; Tsueda, Hisanobu. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. (In Japanese). In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Coal components extracted with carbon disulfide-N-methyl-2-pyrrolidone mixture(CS_2-MP) were separated by several sorts of solvent. Then, by comparing the property of each fraction, it was tried to characterize the property of coal. The extract of coal with CS_2-MP was separated by acetone into soluble(AS) and insoluble, and the latter was further separated by pyridine into soluble(PS) and insoluble(MS) components. More MS fractions were obtained from coal with higher yield in extraction with CS_2-MP, and the difference in extraction rate was mainly caused by the amount of MS components. The H/C atomic ratio was highest in AS and lined up in the order of AS>PS>MS>residue (in extraction with CS_2-MP). The O/C atomic ratio lined up in the reverse order. The structural parameter was studied on each fraction using ^{1}H-NMR. Results of analysis showed that the rate of aromatic carbon (f_a) was highest at MS and lined up in the order of MS>PS>AS, meaning that MS was rich in heavy component. Moreover, parameters such as the condensation of aromatic ring were compared on each coal type and fraction, and the structural characteristics of coal were discussed. 2 refs., 5 figs., 2 tabs.

6731 (NEI-DK–240) **Investigation of the physical characteristics of various types of coal: Characteristics related to dust and handling.** Energiministeriets Energiforskningsprogram. Braendsler og forbraendingsteknik. Holland, D.; Westborg, S. DK-Teknik, Soeborg (Denmark). Oct 1989. 86p. (In Danish). Contract EM-1323/86-4. Order Number DE90728153. Available from NTIS (US Sales Only), PC A05/MF A01.

EFP-86.

In relation to the handling and storage of coal, hitherto unforeseen problems of excessive dust generation and plugging in siloes and conveyors can arise. The "Rotating-drum dust-emission test" reveals the "Critical moisture content" which defines the condition where the type of coal examined begins to release dust. By testing 5 different types of coal a quite remarkable merging of the critical moisture content with the ASTM standard method's "Equilibrium moisture" (maximum content of pore-held moisture) has been found. The "Critical moisture content" then, describes to what extent the moisture content is to be found in the pore structure and consequently is not able to bind the fine particles. Thus the lower limit for the coal's moisture content can be determined, and as a result of this it is possible to avoid dust problems. The Jenike Direct Shear-test has been used to find the flow parameters and determine coal handling characteristics. The immediate and time dependent float functions of the coal as well as the wall friction in relation to different materials have been determined as a function of the moisture content. Results show that the ability of the coals to flow unhindered is reduced by increasing the free moisture content. The ability of the coals to flow unhindered is reduced by increasing the free moisture content. No maximum was found for the coals handleability within the investigated levels for surface moisture content. The moisture content must be unrealistically high in relation to the natural moisture content, before maximum handleability is achievd. It is indicated that in order to flow unhindered coal must be either sopping wet (slurry) or as dry as possible. The method is both resource- and time-consuming it is not recommended for routine use. (AB).

6732 (VTT-SYMP–98, pp. 35-59) **Drying and processing methods for Kansk-Atshinsk coals in power economy.** Pronin, M.S. (Vsesopeznyj tenloteknitceskij institut im. Dzerzhinskogo (USSR)). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (In Finnish, Russian). (CONF-8701165–: Seminar on comparison of drying methods of wet coal and peat, Jyvaeskylae (Finland), 6 Jan 1987). In *Comparison of drying methods of wet coal and peat.* Order Number DE90728211. Available from NTIS (US Sales Only), PC A09/MF A01; NTIS (US Sales Only), PC A09/MF A01.

The properties of brown coal of Kansk-Atshinsk area are described in this presentations, as well as the drying and processing methods of it for utilization in the molten slag furnaces and solid slag furnaces. The fuel milling and transportation equipments and their operating parameters, as well as the prevention of explosion hazards while using coaldust as fuel are presented.

6733 Relation of slag viscosity and surface tension to sintering potential. Miller, S.F. (Pennsylvania State Univ., University Park (USA)); Kalmanovitch, D.P. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 42-49 (1988). (CONF-8806316–: Ash chemistry of coal, Toronto (Canada), 5-10 Jun 1988).

The purpose of this paper is to discuss the relative effect of viscosity and surface tension on sintering potential or agglomeration in coal utilization systems. Of specific interest is the effect of composition and atmosphere on viscosity and surface tension. The discussion here suggests the following relationships: (1) Slag viscosity decreases while surface tension increases under a reducing atmosphere. The net result is increased sintering potential of an ash in a reducing versus oxidizing environment, (2) An increased silicon dioxide content increases the viscosity of a slag at a greater rate than the surface tension of the slag. The net result is reduced sintering, (3) An increased sodium oxide content (possibly total alkali content) decreases the viscosity of a slag at a greater rate than the slag surface tension. The net result is an increase in sintering, and (4) Those ashes which tend not to sinter or agglomerate form molten phases which have higher viscosities relative to their surface tension at a given temperature and those ashes which tend to agglomerate form molten phases which have lower viscosities relative to their surface tension at a given temperature.

6734 Evaluation of coal-mineral association and coal cleanability by using SEM-based automated image analysts. Straszheim, W.E. (Iowa State Univ., Ames (USA)); Younkin, K.A.; Markuszewski, R.; Smit, F.J. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 64-72 (1988). (CONF-8806316–: Ash chemistry of coal, Toronto (Canada), 5-10 Jun 1988).

A technique employing SEM-based automated image analysis (AIA) has been developed for assessing the association of mineral particles with coal, and thus the cleanability of that coal, when the characteristics of the separation process are known. Data resulting from AIA include the mineral distribution by particle size, mineral phase, and extent of association with coal. This AIA technique was applied to samples of −325 mesh (−44 μm) coal from the Indiana No. 3, Upper Freeport, and Sunnyside (UT) seams. The coals were subjected to cleaning by float-sink separations at 1.3, 1.4, 1.6, and 1.9 specific gravity and by froth flotation. For the three coals, the float-sink procedure at a given specific gravity produced different amounts of clean coal, but with similar ash content. Froth flotation removed much less ash, yielding a product ash content of ~8% for the Upper Freeport coal, regardless of recovery, while reducing the ash content to less than 5% for the other two coals. The AIA results documented significantly more association of minerals with the Upper Freeport coal, which thus led to the poor ash reduction.

6735 **The conversion of organic sulfur in coal to sulfate using perchloric acid.** McGowan, C.W. (Tennessee Technological Univ., Cookeville (USA)); Cates, K.Q.; Markuszewski, R. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 225-231 (1988). DOE Contract W-7405-ENG-82. (CONF-8806313–: Sulfur chemistry in coal, Toronto (Canada), 5-10 Jun 1988).

Based upon the authors' previous research in which the variable oxidizing power of perchloric acid ($HC10_4$) was used to determine directly the organic sulfur in coal, it was hoped that this property of $HC10_4$ could be also used to determine different forms of organic sulfur in coal. This preliminary investigation into the usage of $HC10_4$ to delineate between various organic sulfur forms was based on model compounds. Dibenzothiophene, benzothiophene, diphenyl sulfide, 2-naphthalenethiol, dibenzyl disulfide, and dioctyl sulfide were oxidized in a Bethge apparatus with $HC10_4$ of varying concentration and boiling point. To insure complete sulfur recovery, gases produced during the reaction were captured in a trap containing hydrogen peroxide. Sulfate was then measured nephelometrically, after precipitation as barium sulfate, in the residual $HC10_4$ solution and in the peroxide trap. No appreciable amount of sulfate was measured for the aromatic compounds until a temperature of 170 C or higher was reached. However, for dibenzyl disulfide and dioctyl sulfide, large amounts of sulfate were measured in the trap, even at lower temperatures. The volatility of these two compounds may be a contributing factor in their high conversion to sulfate.

6736 **Correlation between refractive indices and other fuel-related physical/chemical properties of pyrolysis liquids derived from coal, oil shale, and tar sand.** Khan, M.R. (Department of Energy, Morgantown, WV (USA)). *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 223-234 (1988). (CONF-8806318–: Low temperature pyrolysis, Toronto (Canada), 5-10 Jun 1988).

In the literature, characterization techniques based upon the liquid's refractive index are used with petroleum distillates to predict fuel-related properties; however, essentially nothing has been reported on the application of this technique to pyrolysis liquids. Measurements of the refractive indices of the pyrolysis liquids derived from various feedstocks (coal, oil shale, and tar sand) were made and appear to correlate well with the liquids' physical and chemical properties. The refractive indices of the pyrolysis liquids show good correlations with liquid density (correlation coefficient of 0.98), carbon and proton aromaticities (correlation coefficients of 0.88 and 0.91, respectively), and liquid carbon residue (i.e., correlation coefficient of 0.88 with the Conradson carbon residue). The above and other correlations were developed using data from at least 7 to as many as 35 discrete samples. These correlations have been used to develop empirical models. These findings demonstrate the potential of using the liquid's refractive index as a rapid technique to characterize the fuel-related properties of fossil fuel liquids generated by pyrolysis (before they are hydrogenated).

6737 **Prediction of the composition of coal tars from the pyrolysis mass spectra of the parent coals using canonical correlation techniques.** Chakravarty, T. (Univ. of Utah, Salt Lake City (USA)); Meuzelaar, H.L.C.; Jones, P.R.; Khan, M.R. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 235-241 (1988). (CONF-8806318–: Low temperature pyrolysis, Toronto (Canada), 5-10 Jun 1988).

In this study, the authors show that the mass spectrometric composition of coal tars can be predicted from the pyrolysis mass spectra of their parent coals. Curie-point low voltage electron ionization mass spectrometry (CuPy-EIMS) was performed on nineteen coals and on their respective pyrolysis liquids prepared by means of a fixed bed reactor method described elsewhere. Using factor and discriminant analysis techniques, the spectra can be classified and underlying structural variables responsible for the above classification identified. Furthermore, compositional similarities and dissimilarities between the solid samples and their liquids can be brought out using canonical correlation methods. Table I lists the samples, their PSOC numbers, geological origin and the rank information. Of the nineteen coal samples, two are of subbituminous rank, three of high volatile B and C bituminous rank and the remainder of high volatile A bituminous rank. Twelve coals are from the Eastern/Appalachian coal province, six are from the Interior province and one is a Western coal from the Northern Great Plains province.

6738 **EXAFS investigation of organic sulfur in coal.** Huffman, G.P. (Univ. of Kentucky, Lexington (USA)); Huggins, F.E.; Shah, N.; Bhattacharyya, D.; Pugmire, R.J.; Davis, B.; Lytle, F.W.; Greegor, R.B. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 200-208 (1988). (CONF-8806313–: Sulfur chemistry in coal, Toronto (Canada), 5-10 Jun 1988).

EXAFS spectroscopy is shown to be a very promising technique for investigating the molecular structure of organically bound sulfur in coal and coal derivatives. The current paper presents sulfur K-shell EXAFS results for a number of a maceral separates prepared by density gradient centrifugation and for several biodesulfurized coals. Both the near-edge structure and the radial structure functions exhibit some similarities to dibenzothiophene. However, a broad peak occurs in the XANES region of the coal spectra that is not observed for the molecular structures usually ascribed to organic sulfur in coal. This is believed to arise from resonant photoelectron scattering from second and third nearest neighbor carbon shells and from sulfur bonded to oxygen.

6739 **The macromolecular structure of coal-its relationship to diffusion and reaction processes in coals.** Suuberg, E.M. (Brown Univ., Providence, RI (USA)); Otake, Yoshi; Deevi, S. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 387-394 (1988). (CONF-8806315–: Storch award symposium, Toronto (Canada), 5-10 Jun 1988).

The present paper is concerned mainly with some rather specific aspects of the problem of characterization of the macromolecular structure of coals, and their relationship to key reaction processes and physical properties. The main characterization technique used throughout this work is solvent swelling, as has been used extensively in recent years to characterize the extent of crosslinking in coals. This classic technique was originally developed for examination of extents of crosslinking in polymers. The present paper considers two entirely different aspects of the relationship between macromolecular structure and reactivity and transport in coals. The first aspect concerns the reactions of crosslinking in coals during thermal treatment. This topic has been previously explored using the solvent swelling methodology. Here the work is extended to consider how the colloidal structure of coal is affected by moisture removal, and by further heating. The second aspect concerns the diffusive transport of solvent species in coals, and the activation energies for such processes.

6740 **Interrelationships between coal analysis, coal conversion and coal structure.** Finseth, D. (Department of Energy, Pittsburgh, PA (USA)); Bockrath, B. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 395-399 (1988). (CONF-8806315–: Storch award symposium, Toronto (Canada), 5-10 Jun 1988).

Studies of the net chemistry of direct liquefaction have focused attention on a number of analytical deficiencies that limit our confidence in describing coal chemistry and/or coal structure. The most obvious analytical limitations are the accuracy of the ^{13}C f_a value, which allows us to quantitatively assess the hydrogenation of aromatics, and the accuracy of the water determination in coal, which determines the accuracy of subsequent measurement of organic

oxygen and hydrogen. These concerns are, of course, not new, but it is important they be kept firmly in mind so that research aimed at resolving our analytical deficiencies can go on simultaneously with our investigations of the relevant chemistry of liquefaction and the structure of coal.

6741 Kinetics of vacuum drying and rehydration of Illinois No. 6 coal samples. Implications for pore structure. Vorres, K.S. (Argonne National Laboratory, IL (USA)); Kolman, R.; Griswold, T. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 333-342 (1988). (CONF-8806136–: American Chemical Society Division of Fuel Chemistry meeting, Toronto (Canada), 5-10 Jun 1988).

The kinetics of vacuum dehydration and rehydration in nitrogen near room temperature have been studied with Argonne Premium Coal Samples. A block, −20 mesh and −100 mesh material wee used. Three types of kinetic behavior were observed in dehydration and rehydration. These included a first order mass change, a combination of some or all of an initial linear, parabolic and final linear (LPL) segments, and a behavior which can be plotted to appear similar to an adsorption isotherm. The mechanisms involved in the linear-parabolic-linear sequence are tentatively assumed to be loss from macro pores, bulk diffusion, and loss of bonded water, respectively. The rates are higher for dehydration in vacuum than for rehydration in nitrogen. The rates increase as the external surface increases from the block through the −20 mesh to the −100 mesh material.

6742 The macromolecular structure of bituminous coals: Macromolecular anisotropy, aromatic-aromatic interactions, and other complexities. Larsen, J.W. (Lehigh Univ., Bethlehem, PA (USA)). *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 400-406 (1988). (CONF-8806315–: Storch award symposium, Toronto (Canada), 5-10 Jun 1988).

A homogeneous piece of vitrinite containing no mineral matter has two organic phases. One of these consists of a crosslinked macromolecular network and the other is a soluble family of macromolecules having a very broad molecular weight distribution. The network is held together by covalent bonds as well as by noncovalent interactions. There is abundant evidence for an important role of hydrogen bonds in the macromolecular structure and growing evidence for an important role for dipole-based interactions between the aromatic groups. These same non-covalent forces are important in binding the extractable phase to the insoluble network. This paper deals with the way the macromolecules pack together in the solid and especially the role that the aromatic-aromatic interactions play in the packing of the macromolecular segments.

6743 Aromatic structures in whole coals and coal macerals. Winans, R.E. (Argonne National Laboratory, IL (USA)); Hayatsu, R.; McBeth, R.L.; Scott, R.G.; Botto, R.E. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(1): 407-414 (1988). DOE Contract W-31-109-ENG-38. (CONF-8806315–: Storch award symposium, Toronto (Canada), 5-10 Jun 1988).

New information on the chemical and physical structure of coals and separated coal macerals strongly suggests that polycyclic aromatics do not dominate the aromatic structure except in the very high-rank coals and in inertinites. Two very different approaches have led to these conclusions. First, a very mild, selective oxidation method has been used to break down the coal macromolecular structure into molecules which can be readily characterized. The products are dominated by single ring aromatics. Second, small-angle neutron scattering has been used to study solvent swollen coals. There is no evidence from the scattering data for the existence of a layered structure, instead long tubular pores are being formed apparently as a result of changes in the hydrogen-bonding in the matrix.

6744 A new determination of exchangeable oxygen in coals. Olson, E.S. (Univ. of North Dakota Energy and Mineral Research Center, Grand Forks (USA)); Diehl, J.W. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 415-421 (1988). (CONF-8806136–: American Chemical Society Division of Fuel Chemistry meeting, Toronto (Canada), 5-10 Jun 1988).

Finseth has recently reported a new method for the determination of water in coals which utilizes isotope dilution. In this technique, a known amount of water which was enriched in ^{18}O was added to the weighed coal sample in a tube. Carbon dioxide was also added and the tube sealed and then heated to equilibrate the added labeled water with the natural abundance water present in the sample. The tube was then opened and the carbon dioxide analyzed by mass spectrometry to determine the isotopic ratio, from which the coal moisture could be calculated. The carbon dioxide acted as a probe molecule to facilitate the mass spectrometric analysis, since its oxygens exchange completely with those of the water. The results of Finseth's moisture determinations were compared with ASTM values for a number of Argonne premium coal samples and were in all cases somewhat larger than the ASTM values. The mass spectrometers available in their laboratories are not adaptable to analysis of the CO_2, hence the authors sought an alternative for the analysis of the isotope ratio in the isotopically equilibrated water samples. The reaction of the water with several orthoesters to give the ester containing the water-derived oxygen (labeled oxygen) in the carbonyl group was investigated. The orthoester selected for the analysis was trimethyl orthobenzoate, since it gave methyl benzoate which could be conveniently analyzed in our GC/FTIR/MS system. Results are discussed.

6745 Determination of compound class composition of oil fractions of some coal liquids by analytical liquid chromatography. Chawla, B. (Kentucky Energy Cabinet Lab., Lexington (USA)); Davis, B.H. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 440-448 (1988). (CONF-8806136–: American Chemical Society Division of Fuel Chemistry meeting, Toronto (Canada), 5-10 Jun 1988).

A high-performance liquid chromatography method was developed to determine the amount of each of the compound classes (such as saturates, aromatics and polars) in the oil fraction (pentane soluble fraction) of coal liquids. The method utilizes bonded cyanosilane and aminocyanosilane columns and mixtures of benzene in n-hexane and tetrahydrofuran in methyl tert-butyl ether as mobile phases. The Tracor LC-rotating disc flame ionization detector was used to quantify the chromatographic peaks. Oil fractions derived from different rank coals, liquefied at 385 and 445 C, were analyzed for their compound class compositions. The trends in the percentages of saturates, aromatics and polars varied with liquefaction temperature and coal rank.

6746 Rapid evaluation of reaction conditions on coal pyrolyzates using coupled pyrolysis GC/MS. Miller, D.J. (Univ. of North Dakota Energy and Minerals Research Center, Grand Forks (USA)); Hawthorne, S.B.; Timpe, R.C. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 455-463 (1988). (CONF-8806136–: American Chemical Society Division of Fuel Chemistry meeting, Toronto (Canada), 5-10 Jun 1988).

The optimization of processes using coal as a carbon source for reaction with steam to produce hydrogen requires an understanding of the composition of the voltaile components released during the charring process. A coupled pyrolysis GC/MS method has been developed to rapidly evaluate the effect of reaction conditions, including catalysts used to accelerate the char-steam reaction on the composition of the coal pyrolyzate. Four samples (one uncatalyzed and three catalyzed with 10 wt% $CaCO_3$, K_2CO_3, and Na_2CO_3, respectively) of a North Dakota (Velva) lignite were pyrolyzed under thelium at 700 C for ten minutes. The volatile products (primarily benzene and alkylbenzenes, phenol and alkylphenols, dihydroxybenzenes, and methoxyphenols) were swept from the pyrolysis chamber directly into a capillary gas chromatographic column and cryogenically trapped prior to GC/MS analysis. While simulated distillation plots for the uncatalyzed Velva and three catalyzed samples were similar, dramatic reductions in the amounts of catechols and guaiacols were observed in the K_2CO_3 and Na_2CO_3 catalyzed samples.

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Refer also to citation(s) 6692, 6796, 6803, 6813, 7480, 7496, 7507, 8184, 8405

6747 (CMRC–8901, pp. 139-151) **Technical trends of coal ash utilization in foreign countries.** Nagano, Takuzo (Onoda Cement Co., Ltd., Yamaguchi, Japan). Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Technical topics are presented from the papers of the 7th International Ash Utilization Symposium. A Canadian research institute describes the recovery techniques of cenospheres, magnetite and carbon, and in particular, the value of cenospheres as a light inert filler is emphasized. EPRI (Electric Power Research Institute, U.S.A.) expects that fly ash is widely used as an asphalt filler, road substratum matter and others for highways, because only 27% of whole fly ash produced in the U.S.A. can be utilized even if whole produced cement can be mixed with fly ash up to 20%. EPRI comes to the conclusion that a DAL (direct acid liach) process is most economical and realistic among various recovery processes of valuables from fly ash, because fly ash can be utilized without any losses, and the DAL process is economical based on a cost benefit analysis, except a few kinds of coal ash containing much alkali such as Ca, and can also settle, at the same time, various pollution problems. 4 refs., 3 figs., 5 tabs.

6748 (CMRC–8901, pp. 152-207) **Fundamental tests on recovery of valuable matters from coal ash.** Murakami, Toru (The Coal Mining Research Centre, Japan, Tokyo, Japan); Kumamoto, Junji; Sasaki, Yutaka. Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Research results in 1986 were reported on the development project to recover the valuables in coal ash promoted since 1984. As for physical treatment, the fundamental data such as the recovery of fly ash magnetite (FAM) was gathered, and a wet roughing-wet cleaning benchmark equipment was tested. As for a direct acid leaching (DAL) process as chemical treatment, the solubility of fly ash was examined using the mixture of hydrochloric acid and hydrofluoric acid as solvent possible to solve mullite to enhance the extraction of Al, and the separation of Al, Fe and Ti elements in solution was basically tested by a solvent extraction method. While to improve the lower Al extraction of the DAL process, fly ash characteristics and the effects of CaO additives and sintering conditions on sintered products in a calsinter process were examined, and the solvent extraction of valuables from the sintered products was tested using sulfuric acid. 14 refs., 76., 15 tabs.

6749 (CMRC–8901, pp. 270-284) **Utilization technology on slurried ash.** Kanbe, Yoshio (The Coal Mining Research Centre, Japan, Tokyo, Japan); Yasuda, Minoru; Furuki, Yasuhiko. Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Three research results of the utilization technology on slurried ash were reported. As for the utilization as the fly ash quick setting (FQS) backfill grout for tail void in shield works of tunneling, grout blending was simplified, the blended solution of cement, clay, additives and water was stabilized, and a favorable workability and long term durability were obtained. As for the utilization as the material of a SMW (soil mixing wall) method for continuous walls in long shaft digging, a fly ash-gypsum-cement (FGC) stabilizer showed an excellent workability and remarkably high water-tightness as compared with conventional cement bentonite. As for the utilization as the material of an injection method of overlay mats in foundation works of light weight structures on the sea bed mud foundation, since a FGC concrete weight in water was remarkably light as 0.7t/m^3, no both large mold form strength and vibration compacting were required. 10 figs., 8 tabs.

6750 (CMRC–8902, pp. 47-81) **Fundamental tests on recovery of valuable matters from coal ash (Part 2).** Murakami, Toru (The Coal Mining Research Centre, Japan, Tokyo, Japan); Onoda, Mamoru; Sasaki, Yutaka. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

A basic test and bench-scale test were made in order to recover valuable matter from coal ash. In Japan, more abundant in coal than oil in reserves, coal, as stable energy supply source, is expected to annually increase in consumption quantity. Accordingly, the effective utilization of coal ash steadily progresses in technological development, which is inclusive of recovery of valuable matter from coal ash. This research has the purpose of recovering magnetite from coal ash by means of magnetic separation. As a result of test, in the basic test on the recovery method of fly ash magnetite in coal ash, fly ash was so largely different by kind in magnetization ratio that its maximum and minimum were 20% of Datong coal and 0.9% of Miike coal, respectively. Datong coal was 77.3% in assay grade of magnetized matter. The dry roughing than the wet roughing for each kind of coal ash was larger in magnetization ratio and smaller in assay grade of magnetized matter. Also a test by two kinds of chemical treatment method was made. 12 refs., 49 figs., 16 tabs.

6751 (CMRC–8902, pp. 82-112) **The experimental test results-in construction material application of coal flyash produced by coal-fired combustion boilers using in general industries excepting for electric power plants, steel product, etc.** Miwa, Tuguhisa (The Coal Mining Research Centre, Japan, Tokyo, Japan); Sakamoto, Norinaga; Ikeda, Hiroshi; Kataoka, Yoshinao. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

For the construction material application of coal flyash, an embankment test and full-scale road construction test were made. The use of coal in the general industry is expected, in future, to expand to the petty demand, with the production of coal flyash in small quantities at multiple spot. Therefore, the recovery by regional groups to utilize it for the construction material application is superior to the disposal by the reclamation. As result of the embankment test, coal flyash, though applicable as construction material judged from its compaction characteristics, CBR value, etc., must be taken a sufficient care of in water content control. To obtain the specified strength, the addition with stabilizer is often necessary, which addition is different in quantity by the flyash quality. In the full-scale road construction test, newly produced coal flyash added with 2% cement and 1% gypsum, humidified, kneaded and embankment cured for a period of about three months was found stable against the rain. In a six-month pursuit survey on the test pavement road after the commencement of use, the concrete surface was found stable without fissures. 45 figs., 24 tabs.

6752 (CMRC–8902, pp. 113-127) **Present situation of effective utilization technology of coal ash.** Miwa, Tsugihisa (The Coal Mining Research Centre, Japan, Tokyo, Japan); Yasuda, Minoru; Furuki, Yasuhiko. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

The Coal Mining Safety Research Center had, those ten years in a research collaboration with many enterprises, investigated coal ash in physical condition and developed a utilization technology of it, of which the summary was reported. During the ten past years, coal was changed in supply source, domestic to overseas, and heightened in dependence ratio on coal overseas, which was, from many countries of the world, so diversified in coal and ash properties that the conventional utilization technology of coal ash came to be problematic. In the coal characteristics, foreign coal is generally less ashy than domestic coal, which is judged to be due to the highness in calorie of foreign coal. In fusing point of ash, foreign coal is generally higher than domestic coal. While in fuel ratio (ratio of solid content to evaporative content), domestic coal is higher than foreign coal, which delicate difference in combustion condition seems to influence the granular formation of flyash. The developed reformation and utilization technology, and present worldwide utilization status of coal ash were also explained. 9 figs., 12 tabs.

6753 (CRIE-U–88038) **Effects of light intensity on the growth of gametophytes and on the growth of juvenile sporophytes of eisenia bicyclis and ecklonia cava (Laminariales, Phaeophyta).** Goto, Hiroshi; Ito, Yasuo. Central Research Inst. of Electric Power Industry, Abiko, Chiba (Japan). Nov 1988. 30p. (In Japanese). Order Number DE89910293. Available from NTIS (US Sales Only), PC A03/MF A01.

In order to utilize the coal ashes from a coal fired power plant, the study of marine macrophyte beds creation using concrete blocks which were mixed with the coal ashes, was carried out. The reaction between the light intensity which is closely related to the depth of water and the growth of laminariacese macrophyte was clarified. Furthermore, the basic data for the marine macrophyte beds creation were studied. Gametophytes and juvenile sporophytes of Eisenia bicyclis and Ecklonia cava were cultured for 20 days under the conditions as follows: water temperature 20 $\pm$ 0.5°C; light intensity 0, 25, 50, 100, 200, 400, 800, 1300 $\mu E/m^2/s$ (abbreviated to eμE); photoperiod 12/12h. The gametophytes of the two species showed maximum growth at 100 μE and growth rate reduced at more than 200 μE. On the other hand, the sporophytes of the two species showed maximum growth at 400 μE, indicating a greater light demand than that gametophytes. 12 refs., 15 figs., 5 tabs.

6754 (DOE/PC/88927–5) **Mechanistic and kinetic studies of high-temperature coal gas desulfurization sorbents: Quarterly progress report No. 5, July–September 1989.** Lew, S.; Flytzani-Stephanopoulos, M.; Sarofim, A.F. Massachusetts Inst. of Tech., Cambridge, MA (USA). Dept. of Chemical Engineering. Oct 1989. 25p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FG22-88PC88927. Order Number DE90004267. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

During this quarter, experimental studies of reduction of ZnO-TiO_2 sorbents in the presence of H_2O were completed. Water vapor represents an important parameter in the reaction because it is a major constituent in hot coal-derived gas streams. H_2O content varying from 50 vol% in a fixed bed Lurgi gasifier to 10 vol% in a fluidized bed KRW gasifier is typical. It has also been reported that the presence of water vapor may significantly affect the reduction of zinc oxide. A more in-depth examination of the sulfidation of the ZnO-TiO_2 sorbents was also performed. A microscopic analysis of the physical as well as chemical changes accompanying sulfidation of the sorbents is discussed. This portion of the project will serve to aid the modeling of ZnO-TiO_2 sulfidation. 17 refs., 11 figs., 2 tabs.

6755 (LBL–27956) **The continuous crystallization of sulfur formed by the liquid-phase reaction of hydrogen sulfide and sulfur dioxide.** Stevens, C.A.; Lynn, S. Lawrence Berkeley Lab., CA (USA). Sep 1989. 199p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC03-76SF00098. Order Number DE90003991. Available from NTIS, PC A09/MF A01 - OSTI; GPO Dep.

The crystallization of elemental sulfur is a unit operation in a process being developed to remove hydrogen sulfide from industrial gas streams. The sulfur is formed by the irreversible, liquid-phase reaction of hydrogen sulfide (H_2S) and sulfur dioxide (SO_2). Low-temperature sulfur solubility data in triethylene glycol dimethyl ether (Triglyme) and diethylene glycol methyl ether (DGM) were collected. The effects of temperature and water concentration in the solvents on sulfur solubility were correlated. The thermal crystallization of sulfur from Triglyme was studied in a laboratory-scale experimental crystallizer. The dependence of crystal-size distribution on residence time, slurry density, impeller power input, and water concentration in the solvent was determined. A crystallization model, applicable to the experimental crystallizer, was derived from population balance theory and verified using the experimental data. The crystallization kinetics of the sulfur/Triglyme system were obtained from the crystallization model. The reactive crystallization of sulfur formed by the reaction between H_2S and SO_2 was also studied. A reactor/crystallizer model was developed from the reaction kinetics and from the thermal crystallization kinetics. Reactive crystallization experiments verified the model. An industrial-sized reactor/crystallizer was designed from the model. 53 refs., 44 figs., 18 tabs.

6756 (NEI-DK–226) **First Nordic conference on sulfur dioxide and nitrogen oxide reduction in relation to combustion of solid fuels.** Johnsson, J.E. (ed.). Danmarks Tekniske Hoejskole, Lyngby (Denmark). Inst. for Kemiteknik. Dec 1988. 164p. (In Danish). (CONF-8810456–: 1. Nordic conference on sulfur dioxide and nitrogen oxide reduction in relation to combustion of solid fuels, Lyngby (Denmark), 17-18 Oct 1988). Order Number DE90728077. Available from NTIS (US Sales Only), PC A08/MF A01.

The aim of the conference was the dissemination of results of research carried out in the Nordic countries covering the subjects of the reaction between sulfur dioxide and limestone, and the formation and reduction of nitrogen oxides during the combustion of solid fuels. The main subject areas of the conference were thus the reaction between SO2 and limestone, the production and reduction of NOx in connection with fluid bed combustion and the selective non-catalytic reduction of NO with NH3. (AB).

6757 (OH/RD–88-305-K) **Characterization of solid wastes from limestone and related sorbent injection processes for a acid gas control: Physical and engineering properties.** Johnston, H.M.; Eagleson, K.E. Ontario Hydro Research Div., Toronto, ON (Canada). 6 Jan 1989. 23p. (MICROLOG–89-04448). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

A number of tests were conducted to determine the engineering/physical properties of three (two bituminous-derived and one lignite-derived) samples of furnace sorbent injection (FSI) by-product to provide data for the planning of effective FSI waste management. The relatively flat shape of the moisture-density curves indicates that reasonable compaction densities can be achieved with moisture contents below optimum, thus reducing haulage costs of moist FSI by-product. In terms of unconfined compressive strength development and hydraulic conductivity, the slaked FSI materials show behaviour equivalent to that of fly ash generated by similar coal sources. 2 refs., 4 figs., 6 tabs.

6758 (OH/RD–712G619) **In-furnace sorbent slurry injection for SO_2 control.** Mozes, M.S.; Mangal, R.; Thampi, R; McDonald, M. Ontario Hydro Research Div., Toronto, ON (Canada). Aug 1989. 59p. (CE–02850). Available from Canadian Electrical Association, Research & Development, Suite No. 500, One Westmount Square, Montreal, PQ, CAN H3Z 2P9. Prices: $75.00 NON-MEMBERS; MEMBERS: PRICES UPON REQUEST, FUNDS CAN.

In-furnace sorbent slurry injection for controlling SO_2 emissions from power plant flue gases has been developed at Ontario Hydro's 640 MJ/h combustion research facility. Operating variables such as quality of atomization, sorbent porosity, slurry concentration and addition rate, injection mode, injection temperature, and residence time in the sulphation zone have been optimized. A 3mm twin-fluid atomizing nozzle, producing droplets of 6 μm diameter, was found to be the most effective. Two calcitic limestones and a dolomite from Ontario were tested with a 1.7% S US coal, a 1.5% S western Canadian -US coal blend and a 2.8% S Nova Scotia coal. The Nova Scotia coal was also tested with a Nova Scotia limestone. Optimum injection temperatures are 1200 and 1100 C for the cocurrent and countercurrent injection modes respectively. Sulphur capture for the cocurrent injection mode ranges between 65-70%, while that for the countercurrent mode ranges between 52-64% for the US coal at a Ca/S ration of 3.0. Optimum sulphur capture with highly porous limestones using coals with sulphur content ranging between 1.5 and 83% at a Ca/S ratio of 3.0. Of course, sulphur capture decreases but sorbent utilization increases with decreasing sorbent stoichiometry. Limestone or dolomite injection produces more waste than coal ash alone and is composed of fly ash, CaO and $CaSO_4$. The electrical resistivity of the waste is higher than that of the ash by 1 to 2 orders of magnitude, but within the range where particulate collection by the electrostatic precipitator is not seriously impaired. An addendum to the report gives results obtained since dolomite is found to be the most cost-effective of the additives tested, it is recommended that this additive be considered in an economic evaluation. 15 refs., 17 figs., 11 tabs.

6759 (ORNL/TM–11345) **Using inorganic membranes to separate gases: R&D status review.** Egan, B.Z. Oak Ridge National Lab., TN (USA). Nov 1989. 70p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC05-84OR21400. Order Number

DE90004386. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This report describes the preparation, properties, and utilization of inorganic membranes, primarily emphasizing the research and development aspects related to the separation of gases. Included are definitions, a brief historical background, a comparison of inorganic and polymeric membranes, a discussion of separation mechanisms, descriptions of various preparation or fabrication methods, studies and applications of inorganic membranes related to gas separations, and compilation of information on commercially available porous materials. The information is evaluated in terms of limitations, needs, and prospects for future development. The major types of gas transport through porous membranes are discussed in terms of viscous flow, free-molecule (Knudsen) flow, surface diffusion, capillary condensation, surface adsorption, ion exchange, and molecular sieving. Membrane preparation and fabrication techniques include: extrusion, powder suspension, molten salt inclusion, phase separation and leaching, nuclear track etching, dynamic deposition, anodic oxidation, pyrolysis, particle dispersion/slipcasting, and thin film deposition. Metallic, porous glass, ceramic, and metallic oxide membranes for separating various gases are tabulated. The needs for improved membrane materials, metal-to-nonmetal seals which will withstand high temperatures and pressures, and better membrane characterization techniques are discussed. 199 refs., 8 tabs.

6760 (STEV-FBT–89-29) **Decomposition of calcium sulphate at reducing conditions in an atmospheric fluidised bed boiler.** Lyngfelt, A. (Chalmers Univ. of Tech., Goeteborg (SE). Dept. of Energy Conversion); Leckner, B. Statens Energiverk, Stockholm (Sweden). Oct 1988. 9p. Project STEV-276-201. (CONF-8810456–2: 1. Nordic conference on sulfur dioxide and nitrogen oxide reduction in relation to combustion of solid fuels, Lyngby (Denmark), 17-18 Oct 1988). Order Number DE90728282. Available from NTIS (US Sales Only), PC A02/MF A01.

Experiments have shown that under normal operating conditions the bed material of a fluidised bed is exposed to reducing conditions. At these conditions the $CaSO_4$ formed from the sulphur capture is not stable and decomposes with a release of SO_2. The rate of $CaSO_4$ decomposition increases with temperature which explains why the efficiency of sulphur capture with lime in a fluidized bed decreases with temperature.

6761 (VTT-TUTK–627) **Emission of peat combustion.** Vesterinen, R. (Valtion Teknillinen Tutkimuskeskus, Jyvaeskylae (Finland). Polttoaine- ja Polttotekniikan Lab.). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). Jul 1989. 92p. (In Finnish). Order Number DE90728183. Available from NTIS (US Sales Only), PC A05/MF A01.

The study is investigating factors that affect gaseous and solid emission formation in different peat combustion process, surveying the information available at the present on the amounts and formation of different emission components. The volatility properties of fuel ash and the size of distribution of particles in ash have an effect on the metal emissions released in combustion. The largest part of the sulphur fed in with the fuel transforms to sulphur dioxide, and is emitted to the air with the flue gases without cleaning. Another part of the sulphur (0.44%) combines with ash. This combination varies according to the combustion technique used, the ash content of the fuel, as well as the alkalinity level of the ash. An increase in the boiler loading increases the sulphur dioxide emission. For instance, when the load in fluidized bed combustion was increased from 65% to 98%, an increase of 10 mg/MJ in dioxide emission occured. The formation of nitrogen oxides is affected by the nitrogen content of the fuel, by combustion conditions and by combustion temperature. In preliminary studies the nitrous oxide emissions from peat combustion have been 5-50 mg/MJ. Emissions of organic compounds are released in incomplete combustion. Research shows that the emissions of polycyclic aromatic hydrocarbons (PAH), when measured against the amount of fuel energy can in fact be 500-50000 times higher from small boilers (such as central heating burners and wood stoves) than from peat-fired power plants.

6762 (VTT-TUTK–629) **Emission measurements of energy production: Intercalibration study of particle, sulphur dioxide and nitrogen oxides emissions.** Vesterinen, R. (Valtion Teknillinen Tutkimuskeskus, Jyvaeskylae (Finland). Polttoaine- ja Polttotekniikan Lab.). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). Jul 1989. 51p. (In Finnish). Order Number DE90728182. Available from NTIS (US Sales Only), PC A04/MF A01.

This report is on an intercalibration study of sulphur dioxide, nitrogen oxides and particles measured at the Rauhalahti power plant on April 11-13, 1988. The measurements were carried out by groups from five laboratories. Various groups used partly the analyzers of different manufactures. All measurements were made during the normal operation of the plant. The particle measurements had to be made from two channels in succession because of the scarcity of measurement levels. Despite the stepwise measuring method, the particle measurements succeeded well. The position of the separation filter in either the channel or outside the channel did not seem to have any great significance. Also, the use of a glass fiber did not in these conditions seem to cause differences in the emission content. There was more variation in the measurement results of sulphur dioxide and nitrogen oxides than with particle measurements. This seems to be partly due to the unrealiability of the calibration gases. One calibration gas for both sulphur dioxide and nitrogen oxides yielded a clearly deviated measurement result from the guarantee value, when the other laboratories were using analyzers calibrated for their own gases. For instance, in a gas analysis made by traditional, extractive sampling from a small data base, a somewhat greater nitrogen oxide content could be detected than when the sampling was done with a diluting stack probe. In future emission measurements special attention should be given to the calibration of the measuring devices and to the reliability of the calibration gases.

6763 **A granulation/sintering method for the codisposal of solid residues from coal conversion processes.** Burnet, G. (Iowa State Univ., Ames (USA)); Gokhale, A.J.; Meisinger, R.F. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA)*, 33(2): 103-111 (1988). DOE Contract W-7405-ENG-82. (CONF-8806316–: Ash chemistry of coal, Toronto (Canada), 5-10 Jun 1988).

A stabilization process for coal cleaning and coal combustion-related wastes has been developed that uses the energy derived from the fuel contained in the coal cleaning waste. The wastes are pulverized, when necessary, formed into granules in a rotary pan agglomerator, and then fired to a sintering temperature. The resulting readily disposable product consists of rock-hard granules that are highly resistant to environmental degradation. The green (non-dried and nonfired) granules satisfy durability tests that measure the capability to be handled and stored. The sintered granules meet requirements of the standard ASTM and EP leaching tests and a freeze-thaw cycle test. The strength of the sintered granules compares favorably with the strength of natural aggregates. The process has been applied to coal cleaning refuse alone and to refuse/fly ash and refuse/FGD sludge mixtures.

6764 **Numerical modeling of direct sorbent injection for SO_2 removal.** Lee, J.J. (Univ. of Tennessee Space Institute, Tullahoma (USA)). *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA)*, 33(2): 120-125 (1988). (CONF-8806317–: Mathematical simulation of coal conversion processes, Toronto (Canada), 5-10 Jun 1988).

A modeling study of steady, turbulent, reactive multi-phase flow in a duct injection flue gas desulfurization (FGD) system is reported in this paper. The stream-function/vorticity method was used in finite difference form. The κ-ϵ model was used for turbulence closure. A simple integrated formulation was employed to compute the behavior of sorbent droplets injected into the flue gas stream. The sorbent may be injected either as slurry or solution into a hot flue gas, or a dry sorbent may be injected into a cooled and humidified flue gas. A comprehensive heat and mass transfer model was developed to simulate the evaporation of the sorbent droplets and the adsorption/reaction of SO_2 in the sorbent droplets. Dissolution kinetics of lime particles within a slurry droplet was also included in this model to determine the overall SO_2 removal rate. Numerical calculations and comparisons with available experimental data were made and are discussed.

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Refer also to citation(s) 6790, 7679, 8185

6765 (CMRC–8902, pp. 46) **Perspective on the development of energy technology to the 21st Century.** Yoshida, Kunio (The Univ. of Tokyo, Faculty of Engineering, Tokyo, Japan). Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

The development of energy technology to the 21st century was viewed. The first problem is the variation of the environment in connection with energy. For the time being, the relaxation of energy demand and supply is seen. Further, there is anxiety on an economy of enlarged scale, and keen competitions of energies are forecasted. The second one is necessity of the establishment of a basal direction on the technology development of energy. For that, it is required to take notice of the followings; promotion of technologies on energy conservation, development of technologies for energy storage, and diversification of energy supplies. The third one is a role of coal. It is required to cope with environmental problems due to a warm of earth, air pollution and so on. Correspondence to distributed energy system in which coal is utilized, is also one of important energy supply. The fourth one is a long-term subject on energy, development of the total energy systems and development of the Zero emission system are considered.

6766 (ETDE-mf–0732543) **Hydrochemical reaction processes in an aquifer influenced by a mine spoil tip.** Besondere Mitteilungen zum Deutschen Gewaesserkundlichen Jahrbuch. Berk, W. van (Bochum Univ. (Germany, F.R.)). Landesamt fuer Wasser und Abfall Nordrhein-Westfalen, Duesseldorf (Germany, F.R.). 1987. 193p. (In German). Order Number DE90732543. Available from NTIS (US Sales Only), PC A09/MF A01.

The effects of coal waste (mine spoil) disposal on groundwater and sediment quality of an aquifer are described. Besides increased concentrations of Cl^-, SO_4^{2-}, total CO_2, Na^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, up to 6000 ppm total dissolved solids and elevated levels of trace element concentrations (selenium, arsenic, chromium) coal waste disposals cause anoxic-sulfidic conditions in downstream groundwaters. As a consequence of groundwater contamination a change of the chemical and mineralogical composition of aquifer sediments is observed. In groundwaters with elevated pH values and high total CO_2 concentrations a precipitation barrier with authigenic carbonates (Fe^{2+}, Mn^{2+}, Ca^{2+}) and monosulfides (Fe^{2+}) is built up and these elements are enriched in the sediments. Thermodynamical equilibrium computations verify that chemical equilibrium is reached between dissolved components of the contaminated groundwater and authigenic mineral phases and that these reactions control the concentrations of involved components in groundwaters and sediments. (orig./MOS).

6767 (RRTAC–89-2, pp. 263-277) **Diversity and seasonal variety in reclaimed native grasslands.** Nilson, D.J. (Basin Electric Power Cooperative, Stanton, ND (USA). Glenharold Mine); Hirsch, K.J. Alberta Land Conservation and Reclamation Council, Edmonton, AB (Canada). Reclamation Research Technical Advisory Committee. 1989. (CONF-890807–: Symposium on reclamation: a global perspective, Calgary (Canada), 27-30 Aug 1989). In *Proceedings of the conference: reclamation, a global perspective. Volume I.* Order Number DE90724308. Available from Publication Services, Queens Printer, 11510 Kingsway Avenue, Edmonton, Alberta, Canada T5G 2Y5.

Production and cover data from a 216 ha reclamation area were collected between 1982 and 1988 for purposes of determining vegetation success and to evaluate establishment and management practices. Nineteen site types were identified where vegetation differed due to seeding date, mulch type, and reconstructed soil characteristics. Diversity and seasonal variety changes over time are discussed for 3 sites relative to an on-site reference area standard. Data show proper seed mixtures, seeding date, glyphosate (Roundup) treatments, and the use of a native hay mulch can affect species composition and contribute to diverse productive reclaimed grasslands. 8 refs., 9 figs., 6 tabs.

6768 **The integrated forest study on effects of atmospheric deposition.** Johnson, D.W. (Environmental Sciences Div., Oak Ridge National Lab., PO Box X, Oak Ridge, TN (US)); Lindberg, S.E.; Bondietti, E.A.; Pitelka, L.F. pp. 123 of Proceedings of the TAPPI 1986 annual meeting. Tappi Press, Atlanta, GA (1986). (CONF-8603230–: TAPPI annual meeting, Atlanta, GA (USA), 2-5 Mar 1986).

The Electric Power Research Institute (EPRI) acid deposition research program is based upon the recognition that forests are complex, long lived systems, and that understanding how pollutants affect the health of forests will come only from long term basic research on the mechanisms of action. The Integrated Forest Study on Effects of Atmospheric Deposition is one of EPRI's three large, integrated research projects designed to address the forest effects problem. The principal objective of this study is to evaluate the effects of atmospheric deposition on forest nutrient cycling. Specifically, processes regulating the mobility of sulfate, nitrate, hydrogen ions, base cations, and aluminium are studied by monitoring the fluxes of these ions from the atmosphere through various forest ecosystems and by altering N,S, and H^+ inputs in a series of manipulative studies.

0110 Reserves, Geology, and Exploration

6769 (CMRC–8902, pp. 37-45) **Coal deposits related to plate tectonics.** Fujii, Keizo (Geological Survey of Japan, Tsukuba, Japan). Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

The plate tectonics and coal bearing formation field were studied in relation between. Coal, of which the origin is botanical remains, is concentrated in three particular periods, ie., Late Carboniferous-Permian, Late Triassic-Jurassic and Late Cretaceous-Middle Miocene. By the orogenic action in the formation process of Pangea Supercontient in the Late Palaeozoic Era, coal bearing formation in the Carboniferous-Permian Period was made. In continuation, that from the end of Palaeozoic Era to the Mesozoic Era was made, with the decomposition of Pangea. Then, that toward the Tertiary Period was made, with the continental separation and growth. Such a structural movement in terrestial zone by the plate tectonics is deeply related with the coal bearing formation. Thick coal bed worth resource was formed in the deltaic zone, surrounding Gondwana Land, North American continent shield, Eurasian table and other stable continent, and sedimentary baisn, together with a deltaic zone growing in the lowland belt formed therearound, formed in the orogenic belt inside the continent in the Mesozoic and Cainozoic Eras. 11 refs., 4 figs.

6770 (FSJ–8901, pp. 229-232) **Initial diagenesis of coalification using pure components as a model.** Dong, Ji-Zhou (Hokkaido Univ., Faculty of Engineering, Sapporo, Japan); Kato, Takashi; Ito, Hironori; Ouchi, Koji. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

It is known by analysis of the extracts and hydrogenated products that a lot of straight chain alkylated compounds of neutral or polar aromatics exist in coal structure, but no report on the formation process is presented. In this study, the origin of formation was examined using model components. Phenol and linear fatty acid were reacted using activated clay as a catalyst at 200 - 300°C in an autoclave, consequently a lot of straight chain alkylated aromatics were found. Existence of these compounds was very similar to the distribution of hydroxyalkyl aromatics and straight chain alkylated aromatics which were found in the mild hydrogenated products of coal. Therefore, initial processes of coalification are estimated as follows: firstly, phenol nucleus of lignin origin is alkylated by alcohol or fatty acid which is formed through hydrolysis of lipid, and then cyclization, transition, dehydration and so on are taken place gradually by catalysis of metals and earth temperature. 5 refs., 2 figs., 1 tab.

6771 (FSJ–8901, pp. 233-236) **Mechanism of formation of coal at Fushun coal mine in China.** Fujii, Keizo (Geological Survey of Japan, Tsukuba, Japan); Suzuki, Yuichiro; Li, Sitian; Wang,

Sheng-Wei; Zhuang, Xin-Gue. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Fushun coal mine was formed in the Paleogene period in the northeastern province of China. The coal layer is more than 60m thick at the thickest part, and the thickness of the layer and the coal property differ remarkably in the east-and-west direction. Coal samples were collected from the three pits to the east of the western pit where coal is mined st present. Proximate analysis, elementary analysis, calorific value, Gieseler fluidity, coal petrographic constituents and Vitrinite reflectance of the coal samples were measured. Coal property characteristics, dump environment and horizontal and vertical changes in coal rank were studied, and the coal formation process of Fushun coal was investigated. Average reflectance of each pit is 0.6, 0.64, and 0.78. Topographical depth differences among the three pits do not influence the coal rank. Few changes are recognized in the lithofacies of the soil that covers the coal layer and in the thickness of the layer. Therefore, it can be concluded as follows. As there was a heat source by igneous activity deep in the eastern part of this area, the coal rank decreased from the east toward the west. 4 refs., 5 figs.

6772 (FSJ–8901, pp. 237-240) **Relationship between coal properties and geologic structure in the Western Canadian coalfields.** Fujii, Keizo (Geological Survey of Japan, Tsukuba, Japan); Okada, Kiyofumi. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

The relation between coal properties and geological structure was studied in North American Craton and Canadian Cordillera. From the end of the Paleozoic era to the beginning of the Mesozoic era, an ocean crust of the western ocean bumped with and went onto North American Craton which was a continent crust on the east, and in the Triassic period the movement of the ocean bottom stopped. In the Jurassic and Cretaceous periods, a part of the ocen bottom went under another or parts of the ocean bottom bumped with each other on the west owing to the eastward compressive force of the ocean bottom. Thus the present geological structure was created. The structure is quite different between the east and the west divided by the Rocky Mountains. North American Craton formed a wide and stable coal sedimentary base in the Cretaceous and the Peleogene periods, the age of coal formation, and was not influenced by igneous activities. The State of Alberta produces sub-bituminous coal, and other states produce brown coal and bituminous coal. In this area, the coal layer is thick, and the coal properties have little variation. In Canadian Cordillera, on the other hand, the stratum of the coal formation age went under strong influences of igneous activity heat, and the coalification progressed partially. The coal layers are, therefore, found partially and discontinuously in small-scale grabens. The coal here has much ash content. 3 refs., 3 figs.

0120 Mining

Refer also to citation(s) 6766, 6820, 7897, 8355

6773 (CMRC–8902, pp. 180-198) **Coal resources in the Illinois basin.** Iwabuchi, Yoshihiro (The Coal Mining Research Centre, Japan, Tokyo, Japan); Kanbayashi, Yutaka. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

Relatedly with supplying coal for liquefaction use to the pilot plant, bituminous coal produced in the Illinois Basin, USA, as candidate coal for that use was prepared in geological site survey together with sampling. The liquefaction reaction is influenced by the carbonic characteristics. Therefore for the evaluation of coal field, it is necessary to grasp the relation between the change in coal bed and carbonic properties, and liquefaction characteristics. Coal from Illinois Basin is classified into upper Mississippian and lower Pennsylvanian. The optimized parts for the open cut coal mining are the south-western part and southern part in Illinois Basin. The optimized coal for the underground mining is Herrin coal, which is generally high in sulfur content, 3 to 5% and more than 0.4 to 0.5% in chlorine content, which is not good and heightens with the deepening in underground level. Almost all of it belongs to highly evaporative bituminous coal. Herrin coal bed, as known, as a result of survey, to be the most important, was investigated in detail. 3 refs., 14 figs., 7 tabs.

6774 (DOE/FE–90004224) **Coal cost chains.** USDOE Assistant Secretary for Fossil Energy, Washington, DC (USA). Office of Coal Utilization, Advanced Conversion and Gasification. Sep 1984. 46p. Sponsored by U.S. DOE Fossil Energy. Order Number DE90004224. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This study represents one of three reports on conventional fossil fuel cost chains – a report on natural gas costs, a report on petroleum costs, and a report on coal costs. This report contains an analysis of five coal cost distribution chains that show the distribution of costs from extraction to the end market. In this report, we identify systems employed in coal mining, preparation, and transportation, along with estimates of each systems component costs. 12 refs.

6775 (ETDE-mf–0732507) **Investigations on the early detection of an underground belt conveyor fire by the LIST temperature sensor system. Summary.** Versuchsgrubengesellschaft m.b.H., Dortmund (Germany, F.R.). 16 Oct 1986. 66p. (In German). Order Number DE90732507. Available from NTIS (US Sales Only), PC A04/MF A01.

In the experiments carried out, the 'LIST' system measured temperature changes of only a few tenths of a degree. As the control and evaluation unit took the temperature drift of the sensor cable due to the environment into account, the alarm thresholds could be set correspondingly low. In the glowing fire experiments carried out, the site of the fire could be detected before the alarm threshold was reached, due to changes in the differential temperature profile. As the sensors can only react to a source of heat, if they are affected by heat radiation or the heated air, the sensor cable should be laid so that it is screened as little as possible by the conveyor belt from the supporting rollers. Heated upper belt rollers were only detected if the sensor cable was laid on the side of the hot roller. Conduction of heat via the belt to the opposite side of a hot upper belt roller was not observed in the given experimental conditions. (orig.).

6776 (STEV-TORV–89-7) **Peat technique PEAB.** Aakesson, T. (PEAB Transport och Maskin AB, Oerkelljunga (SE)). Statens Energiverk, Stockholm (Sweden). 1989. 20p. (In Swedish). Project STEV-215-001. Order Number DE90728292. Available from NTIS (US Sales Only), PC A03/MF A01.

New harvesting techniques have been developed. The development comprises deep digging and replacing top layers after excavation. Peat is pressed into large cylinders and dried on a separate field outside the harvesting area during early summer. Production of sod peat is calculated to take place during the whole year. Investment costs are estimated to be much lower than for conventional techniques. (G.B.).

6777 (VTT-TIED–1013) **Event based simulation of milled peat production.** Hillebrand, K. (Valtion Teknillinen Tutkimuskeskus, Jyvaeskylae (Finland). Polttoaine- ja Polttotekniikan Lab.); Paappanen, T. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). Jun 1989. 63p. (In Finnish). Order Number DE90728185. Available from NTIS (US Sales Only), PC A04/MF A01.

In this publication, numerical simulation in the milled peat production system is described. A general purpose simulation language SLAM II has been used for modeling the Haku production system, which is at present the most common used milled peat production method in Finland. The basic concept of the model is the moisture content of milled peat which changes during the drying periods. The successive stages of production - milling, harrowing, ridging and loading - are connected to the moisture content of peat. The production consists of periodically repeated harvesting cycles. The simulation model can be used to examine peat production as a continuous process, and also to investigate the factors affecting the production separately, which is not an easy task on field conditions because of large sum of parameters. The simulation model provides

extensive capabilities for examining the effects of resources available, machine failure and weather conditions on the production.

0130 Transport, Handling, and Storage

Refer also to citation(s) 6673, 6773, 6788, 6813

6778 (BCR–TP8334E) **Tumbler Ridge branch line electrification demonstration.** Lockhart, H. (BC Rail Ltd., Vancouver, BC (Canada)). BC Rail, Vancouver, BC (Canada). Jun 1986. 21p. (MICROLOG–89-04022). Available from PC Transportation Development Centre (Canada), Complexe Guy-Favreau, 2000 Rene-Levesque Blvd. West, West Tower, Suite 601, Montreal, PQ, CAN H2Z 1Z4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

BC Rail's Tumbler Ridge Branch Line was built between 1981 and 1983 to provide rail access to the north-east coal fields in British Columbia. Because of long grades and heavy tonnages it was decided to electrify the branch line rather than to provide complex ventilation systems in the two long tunnels. This report documents the reasons for electrification, the design, construction and commissioning of the power supply and catenary systems, the testing of the electric locomotives, this power management and the operating and maintenance costs. 9 refs., 2 figs., 3 tabs.

6779 (CMRC–8901, pp. 85-92) **Effect of mill scale-up on the characteristics of CWM.** Ozaki, Hironori (Kawasaki Heavy Industries, Ltd., Tokyo, Japan). Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

To examine the effects of mill scale-up on CWM characteristics, and to obtain the design data for commercial facilities, the CWM characteristics were tested using a 26t/h full scale test facility with a wet ball mill. After mill grinding in the test facility, a part of CWM slurry was stabilized by a bench scale equipment, and the final CWM sample product was subjected to the evaluation of such qualities as a standing stability. The product had 65.5% coal concentration and lower viscosity, and contained only a small amount of coarse particles, nearly 1% over 149micron at 85% under 74micron. These data were approximately equivalent to the bench test data with only a few differences due to scale-up, and the product was also indicated an excellent standing stability without notable sedimentation for two months storage. As the operation results, the scale-up power data required for the facility, and various information for facility starting characteristics or quality control methods were also obtained. 4 refs., 12 figs., 5 tabs.

6780 (CMRC–8901, pp. 108-126) **CCS demonstration test.** Kanbe, Yoshio (The Coal Mining Research Centre, Japan, Tokyo, Japan); Yamazaki, Shigeru. Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Test results in 1986 of the CCS (coal cartridge system) demonstration test initiated in 1985 were outlined. As for the production and supply plant, the results were reported on the blending precision of three coal ranks, the characteristics of circulating gas and condensed water, the changes of pressure, oxygen content, concentration and temperature during and after 650km long distance transportation by bulk rollies, and the changes of CCS coal characteristics due to transportation. As for the combustion plant with a 15t/h small pulverized coal fired boiler, the results were reported on the boiler combustion characteristics as blended coal of low and high grade coal was used, and the boiler load responsibility. As for the industrial furnace plant with a 30t electric steel smelting furnace, the results were reported on the long term storage test of CCS coal in a silo, the ignitability and complete combustion test of a pulverized coal burner, and the power saving effects of different CCS coals. Furthermore, operational problems were also pointed out. 11 figs., 10 tabs.

6781 (CMRC–8901, pp. 208-232) **Development of coal water mixture (CWM) as a fuel for industrial use.** Sakurai, Kazuo (The Coal Mining Research Centre, Japan, Tokyo, Japan); Okigami, Noboru; Ishida, Michio; Maeda, Hiroshi; Jinba, Tadao; Nakai, Shigeyuki; Hongo, Takashi. Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Outlines of the CWM demonstration test project for industrial middle or small boilers were presented, mainly on the CWM production plant and boiler. Both CWM production plant and combustion plant were constructed in the range possible to transport CWM by bulk rollies, and a deashed CWM production facility was also installed in the production plant. 34t/h wet bottom type boiler with a high temperature three-stages combustion system was adopted to reduce NOx emission, and 350kl CWM silo was also installed in the combustion plant. The production facility was composed of a wet type rod mill for rough grinding and two tower mills for normal or fine grinding, and its capacities were set to 5t/h in production and 26,000t in total throughput. Characteristics of CWM slurry were set to about 70% in concentration, 700cP in viscosity, 85% or more thru. 75micron sieve in particle size, and two months in stable state period. 3 refs., 22 figs., 11 tabs.

6782 (CMRC–8901, pp. 293-315) **Feasibility study for application of coal water mixture to industrial boilers in Kinki and Chukyo districts.** Sakurai, Kazuo (The Coal Mining Research Centre, Japan, Tokyo, Japan); Okigami, Noboru; Maeda, Hiroshi. Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

The feasibility for the application of CWM to industrial boilers was studied in the Kinki and Chukyo districts within 200km radius around the Sakai City, Osaka Prefecture. The market research to obtain user needs and the conceptual design of a total system by the joint working group of 15 companies were first carried out in 1985, and in 1986, a system profitability was then evaluated on the basis of calculated results of previous data. On a supply side, a material cost, production cost, transportation cost and ash treatment cost were precisely estimated. On a user side, the profitabilities of oil fired and CWM fired boilers were evaluated on three different boiler capacities. Furthermore, an overall profitability was analyzed considering such fluctuating factors as an exchange rate and coal price, or the balance of demand and supply. As a result, the energy circumstances and system conditions required to introduce the total CWM system were made clear. 3 figs., 30 tabs.

6783 (CMRC–8901, pp. 316-330) **Feasibility study for application of coal water mixture to industrial boiler (Part 2).** Sakurai, Kazuo (The Coal Mining Research Centre, Japan, Tokyo, Japan); Kaneko, Saburo. Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

The feasibility for the conversion of existing oil fired industrial boilers to CWM fired ones was studied under such conditions as the effective use of existing facilities and the minimum conversion of boilers. Three types of oil fired boilers with the maximum continuous evaporation of 215, 150 or 50t/h were selected, and from both technical and economical aspects, the derating of boilers, necessity of a furnace hopper and others were precisely examined applying two kinds of de-ashed CWMs of 7.7 and 0.7% in ash content to each boiler. As a result, no remarkable merit in economics could be expected in the price level of crude oil at 18$/bbl around, however, the collection of a capital investment within five years could be expected at 25$/bbl or more. The annual CWM potential demand of one million tons in 1990 and 5.4 million tons in 2000 were anticipated as a result of the research over the existing industrial boilers of 30t/h or more in the Eastern Japan, though those deeply depended on crude oil prices in the future. 4 fegs., 8 tabs.

6784 (CMRC–8901, pp. 346-398) **Development of CWM as total system in EPDC.** Sakurai, Kazuo (The Coal Mining Research Centre, Japan, Tokyo, Japan); Ikuno, Hiroshi; Motomura, Isamu;

Takahashi, Katsumi; Kajibata, Yoshitaka; Sakai, Makoto; Ito, Masakazu; Ishihara, Toru. Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Results of the total system test and each elemental test in 1986 were reported as a part of the pilot test of CWM preparation test facilities for five years since 1982. On the total system test, the combustion test results of CWM subjected to a coal chain simulation for nine weeks or more after preparation were reported. On the evaluation of CWM properties for the total system, a reliable CWM evaluation method possible to be adopted during its preparation stage was reported. On the CWM transportation test, the test results of degradation, restart, use of pig and the long term performance of a twin screw pump were reported. On the CWM ship transportation test, the test results of various equipment to prevent coal sedimentation were reported. On the CWM cleaning test, the test results of the properties of various de-ashed coals were reported, and the optimal coal cleaning system to obtain a desired ash content was discussed on the basis of the test results. 16 refs., 62 figs., 17 tabs.

6785 (CMRC–8902, pp. 308-320) **Conduct of static electricity noticed while CCS coal dust sample is transported pneumatically.** Nakanishi, Tatsuo (The Coal Mining Research Centre, Japan, Tokyo, Japan); Yamasaki, Shigeru; Ishikawa, Tadao; Fujita, Eiji. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

For the handling of pulverized (CCS) coal, a test was made on its safety in transport. In order to use coal as more efficient fuel, coal is to be pulverized as CCS and transported/stored in large quantities, in which process the statical electrification phenomenon, by the friction/contact of CCS coal being handled, is as well known. Through the test, by utilizing the CCS coal demonstration test facilities, pneumatically conveying CCS coal with nitrogen by a blow-off bulkrolly and measuring statical electricity at the unloading, the electrification energy was calculated. Also, CCS coal was tested in minimum ignition energy. As a result, the kinds of mixed coal used for the test of this time are judged not to cause the occurrence of phenomenon regarded to be dangerous. Even if, for the economic reason, the target in oxygen concentration, less than 10%, is eased, the safety can be secured, which concludes the present control/operation method to be possibly sufficient in safety. 4 refs., 3 figs., 10 tabs.

6786 (CMRC–8902, pp. 321-333) **Conversion of existing oil-firing boiler for industrial use to low ash CWM firing.** Yamaki, Tokizo (The Coal Mining Research Centre, Japan, Tokyo, Japan); Kaneko, Saburo. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

Utilization of deashed low ash coal water slurry(CWM) of ash content reduced to 1 % for altered boiler, was studied, and its outline is presented. Research on the technique to convert the fuel of industrial boiler from heavy oil to CWM, was conducted. Little ash is left on the furnace in oil firing boiler, so the furnace is flat bottom type. However, in the case the boiler currently in use is planned to be altered to adopt CWM, much ash accumulates on the furnace, so the altered boiler has to replace the furnace to hopper bottom type and ash dischargeing equipment is to be added. If dimensions of the furnace is not necessary to be changed, the expence for alteration work is completely saved, provided ash contents is reduced less than one-percent. The unit price of coal necessary to collect in five years the investment for alteration work of two cases, either deashing or without deashing of coal, was estimated. As the result, it is confirmed that deashing of coal is much effective than that without deashing. 3 figs., 7 tabs.

6787 (CMRC–8902, pp. 334-374) **CWM demonstration test.** Sakurai, Kazuo (The Coal Mining Research Centre, Japan, Tokyo, Japan); Yamada, Yoshihiro; Sawada, Morihiko; Sekiguchi, Yoshitoshi; Kimura, Takashi. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

As a series of coal utilization technology, to develop the coal-water-mixture (CWM) technology for the general industry use medium/small size boiler, the research, as reported herein, is being made by the Coal Mining Research Center, Japan in collaboration with ten companies. The utilization of CWM as fuel for the medium/small size boiler has different technological subjects from that for the large boiler. First, the demonstration test for the CWM utilization was determined to be 34ton/h in boiler capacity, to which both the CWM production and combustion bases were specified in various facilities therein to correspond. Next, CWM production, property and other tests were made. While CWM was deashed in the production process. A boiler combustion test by the newly developed high temperature three-stage combustion method was started in 1980, as a result of which the stable combustion is possible with a little influence by kind of coal. NOx can be lowered to less than 150ppm by the adoption of low NOx combustion system and SO_3 is also lowered in production by the high temperature low air ratio combustion. The load follow-up properties, in case of an exclusive combustion of CWM, are almost equivalent to those of heavy oil boiler. 26 figs., 11 tabs.

6788 (EMR/CANMET–CE-02825) **A study of flow conditions arising in horizontal coarse slurry short distance pipelining practice: A proposed Canada/FRG cooperative project.** Geller, FJ Canada Centre for Mineral and Energy Technology, Ottawa, ON (Canada). Jul 1984. vp. (CE–02825). Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

An agreement was signed in 1971 by the governments of Canada and the Federal Republic of Germany on scientific and technical cooperation. Coal slurry systems were identified as one of the several areas in which such cooperation could be usefully undertaken. One field of slurry systems deals with coarse coal-slurry short-distance pipelining. The present report represents proposal for a joint project which has a practical aim of developing methods that will lead to cost-cutting during future slurry-pipeline design work. The fundamental reason for embarking upon the proposed cooperative project is to study ways of better expressing the basic physical principles that govern the hydraulic transport of coarse-slurries in pipelines, and to do so within a broader context than has been successfully accomplished so far. More specifically the objective is to undertake laboratory tests in order to examine and interpret the influence of certain basic physical parameters (such as particle size distribution, viscosity, density and sliding coefficient of friction) upon the accuracy of predictions obtained with a mechanistic two-layer model. The foregoing results are then applied in interpreting and, when necessary, in modifying the two-layer model in question. Special attention is to be paid to the effect of the basic variables upon the ratio of suspended to contact-load solids in the slurries. 1 fig., 3 tabs.

0140 Combustion

Refer also to citation(s) 6657, 6658, 6659, 6660, 6661, 6662, 6663, 6664, 6665, 6666, 6667, 6668, 6669, 6670, 6671, 6672, 6673, 6674, 6675, 6676, 6688, 6692, 6780, 6897, 7478, 7862, 8007, 8008, 8099, 8185, 8406, 8410, 8411

6789 (CMRC–8902, pp. 35-36) **Research and development for coal utilization technology.** Takagi, Hiroshi (The Coal Mining Research Centre, Japan, Tokyo, Japan). Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

A situation of the research and development for coal utilization technology in The Coal Mining Research Centre, Japan was presented. The Research Centre had been devoted to the research and development on coal mining and preparation technologies since The Centre was established in 1960. However, since the change of energy situation in 1973, development for coal utilization technology was newly adopted as a task, and studies on boiler flue gas treatment, low-pollution type fluidized bed combustion, coal handling technique, utilization of the fly ash and formed coke manufacturing

technology, have been conducted. From among study subjects implemented in fiscal 1987, main subjects were introduced by films. The contents are as follows: a demonstration test of 160 ton/h fluidized bed boiler, cement baking using a fluidized bed furnace, a partial combustion furnace using coal, coal-water mixture for boiler, fine coal handling technique, utilization technology of brown coal and subbituminous coal, low calorific coal gasification combined power generation technology, selection and survey (entrusted from NEDO) of coal for liquefaction, utilization of the fly ash and so on. 1 tab.

6790 (CMRC–8902, pp. 211-228) **Development of coal partial combustor.** Yagi, Masafumi (The Coal Mining Research Centre, Japan, Tokyo, Japan); Nakamura, Keizo. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

The outline of bench scale combustion test and boiler simulator experiment conducted as a part of technology development in coal partial combustor (CPC), is presented. Since the oil crisis, the conversion into coal is remarkable in electric utility thermal power/industrial private power generation plant categories, however the conversion in general industries is not advanced yet. Coal Mining Safety Research Center and Kawasaki Heavy Industries Ltd., has been jointly promoted to develop CPC technology and to establish the system to be practically applied to boiler since 1984. About the bench scale test, experiment was conducted with the intension to improve operational performance by alteration of water cooling self-coating system. As the result, it was confirmed that durability of furnace wall of this system is applicable to practical use. And, in order to improve operational performance, combustion test was conducted using four kinds of burner which differ in burner shape and furnace wall construction, and the best burner was selected. Operation control system was improved, based on the above test results and operation support system was developed at the same time. 12 figs., 4 tabs.

6791 (CMRC–8902, pp. 229-244) **Prediction and measurement of burnout and NOx emission in a pulverized coal combustion.** Kanbara, Shinji (Idemitsu Kosan Co., Ltd., Tokyo, Japan); Matsuoka, Shuichi. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A17/MF A01.

An experiment was made on 27 kinds of coal through a laboratory scale swirling flow combustion furnace. In the general industry, fuel for the boiler use has recently come to be often converted with coal, for which use almost all coal is foreign coal with a remarkable variety in properties by origin. Therefore for the selection of coal to be used, it is important to evaluate, in advance, its characteristics. Then without making the combustion test, an experiment to develop a prediction method of produced NOx was made, with use of pulverized coal, more than 100/90% at 100/200 meshpass, supplied, after the inside of furnace was preheated by LPG for about two hours, and ignited by a burner. As a result of predicting the unburnt ratio of actual boiler by the experimental data, the error was +-15%, while than in prediction of produced NOx was +-10%. An NOx INDEX, able to predict NOx in productiveness from the coal properties, was developed with an error of +-15%. 13 refs., 22 figs., 5 tabs.

6792 (CMRC–8902, pp. 282-295) **Pressurized fluidized bed combustion combined cycle.** Takahashi, Masataka (Electric Power-Development Co., Ltd., Tokyo, Japan). Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

The pressurized fluidized bed combustion was explained in principle and characteristics, as compared with the pulverized coal combustion, and reported in present status of technological development. The conversion of coal combustion gas to energy by the turbine had been intended since long ago, however its materialization was difficult, because of combustion gas with high dustiness and corrosiveness. However, by being combined with the fluidized bed combustion, it came to be in expectation to be materialized as a plant. The fluidized bed combustion method is divided into ordinary pressure and pressurized combustion methods. The steam turbine generator being driven by heat generated by the coal combustion, the gas turbine, driven by exhaust gas from the boiler, drives the compressor and generator. While there are the supercharged method and turbocharged method, of which the former is judged, in Japan, to be better than the latter. The pressurized fluidized combined cycle, technologically developed in Japan, America and Europe, has a high efficiency, low public pollution and many other advantages, and is expected, judged from the present status of technological development, to be put to practical use before about 2000. 4 refs., 9 figs., 3 tabs.

6793 (CRIEPI-T–87122) **The modeling of coal-fired boilers.** Yamada, T. (and others). Central Research Inst. of Electric Power Industry, Tokyo (Japan). 1989. vp. (In Japanese).

The modeling available for the optimal control of coal-fired boilers is proposed in this report. In this modeling, fouling by coal ash which has severe effect on the thermal characteristic of coal-fired-boilers can be expressed as a variation in the heat transfer coefficient of tubes. The gas temperature distribution in boilers needed to calculate the above heat transfer coefficient can be estimated from the measurable boiler outlet gas temperature and the quantity of absorbed heat in boiler water. The applicability of this modeling to the commercial 500 MW power station was also verified.

6794 (CRIEPI-W–88008) **Analysis of coal gaseous fuel combustion reaction.** Nakata, T. (and others). Central Research Inst. of Electric Power Industry, Tokyo (Japan). 1989. vp. (In Japanese).

The purpose of this paper is to develop a numerical calculation method for a gas turbine combustor using coal gaseous fuel. An elementary process model was made to describe the chemical kinetics, and thermal nitrogen oxides formation and carbon oxide decomposition in the combustor predicted by solving numerically the time-dependent conservation equations for chemical species. As a result, computation has fitted a variety of experimental data, and we have made considerable progress in developing an accurate chemical kinetics scheme for use in gas turbine combustor design.

6795 (CRIEPI-W–88009) **Development of low load burner system for coal-fired boilers (Part 1).** Koyata, K. (and others). Central Research Inst. of Electric Power Industry, Tokyo (Japan). 1989. vp. (In Japanese).

The coal fired power stations constructed in future are required to be operated for middle load. So it is necessary to develop a low loading burner which assures stable combustion even at the minimum load as achieved by oil-fired power station. In this report, as the first step to developing the low loading burner, the stable combustion conditions, for example, the minimum load of single burner and the ratio of primary air to coal feed rate, are investigated using a pulverized coal combustion test facility.

6796 (CRIEPI-W–88010) **Development of low-NO_x and low ignition loss combustion technology in pulverized coal combustion (Part 1).** Makino, H. (and others). Central Research Inst. of Electric Power Industry, Tokyo (Japan). 1989. vp. (In Japanese).

In this report, the simultaneous low-NOx and low-ignition loss combustion technology by multi-stage air injection method for two-stage combustion is investigated. Main results are as follows: (1) in the case of a single air port, if the combustion rate is over 30%, the NOx concentration increases with the increase of the combustion rate; (2) in the case of plural air ports, if optimum air distribution is achieved, the NOx concentration can be reduced more than the case of single air port, because the re-burning at the two-stage air injection points can be controlled; (3) if plural air ports are optimized, the unburned carbon in fly ash can be reduced to 18% at a NOx concentration of 100 ppm (if the conventional two-stage combustion is used, the unburned carbon in fly ash is 30%.)

6797 (DOE/MC/10637–2761) **Low-rank coal research: Quarterly report, January 1989–March 1989.** North Dakota Univ., Grand Forks, ND (USA). Energy and Mineral Research Center. [1989]. 634p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FC21-86MC10637. Order Number DE90003995. Available from NTIS, PC A99/MF A01 - OSTI; GPO Dep.

Research programs in the following areas are presented: coal gasification, coal combustion, coal liquefaction, coal preparation and SO_x/NO_x control technology, and advanced research and technology development. Nineteen programs are included. Individual projects are processed separately for the data bases. (CBS)

6798 (DOE/PC/79903–T4) **Optical properties of flyash: Quarterly report, 1 July–30 September 1989.** Self, S.A. Stanford Univ., CA (USA). High Temperature Gasdynamics Lab. Oct 1989. 32p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC22-87PC79903. Order Number DE90004022. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The general aims of this research are to provide a fundamental scientific basis for the physical understanding and reliable calculation of radiative heat transfer in coal combustion systems, particularly as it is influenced by the presence of inorganic constituents deriving from the mineral matter in coal. The work is organized and progress is reported under four tasks: (1) Characterization of flyash in which the chemical composition and size distribution of representative flyashes are being measured. (2) Measurements of the optical constants of slags as a function of wavelength and temperature for controlled compositions. (3) Sample calculations of the radiant properties of flyash dispersions. (4) Measurement of the radiant properties of flyash dispersions. 14 figs., 3 tabs.

6799 (DOE/PC/79909–T2) **Pyrite thermochemistry, ash agglomeration, and char fragmentation during pulverized coal combustion: Quarterly report, June 15, 1989–September 15, 1989.** Akhtar, S. Stanford Univ., CA (USA). High Temperature Gasdynamics Lab. Nov 1989. 14p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FG22-87PC79909. Order Number DE90004263. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

During p.f. firing of coal, the evolution of particulate ash from extraneous mineral matter is determined by thermochemistry, agglomeration of molten inclusions as the char is consumed, and fragmentation of the char into finer particulates. Our three-year research program aims for a fundamental understanding of these chemical and physical dynamics, to motivate control strategies for fouling and slagging problems. The transformation of pyrite inclusions into iron oxide ash is the primary focus, including pyrite thermochemistry, the average number of ash particles per char particle, and the relation between the size distributions and composition of mineral inclusions and ash particles. During the quarter June – September 1989, the transformation of iron pyrite suspensions during pyrolysis was monitored at heating rates and furnace temperatures typical of pulverized fuel (p.f.) firing. Solid samples which represent various residence times and thermal histories have been prepared in a radiant suspension flow reactor, and subjected to x-ray diffraction analysis. The relative proportions of pyrite and the aggregate amount of pyrrhotite and iron sulfide melt are reported for furnace temperatures from 1100K to 1550K at a fixed nominal residence time of several hundred milliseconds. In a separate study at a furnace temperature of 1560K, the transient evolution of the iron ash composition is reported for a range of nominal residence times. 6 refs., 5 figs.

6800 (DOE/PC/88859–T8) **Formation and destruction of nitrogen oxides in coal combustion: Seventh quarterly report, July 1, 1989–September 30, 1989.** Chen, Wei-Yin; Lester, T.W.; Babcock, L.M.; Burch, T.E.; Tillman, F.R. Louisiana State Univ., Baton Rouge, LA (USA). Nov 1989. 36p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC22-88PC88859. Order Number DE90004264. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

An entrained coal feeder was constructed for the continuous feeding of coal into the flow reactor. The sampling train and analytical procedures were modified for proper collection of char and for the prevention of sulfide ion interference in the wet chemical analysis for HCN. Reburning of isotopically labelled $N^{15}O$ with Pittsburgh #8 coal was conducted, and the isotopic distribution in NO, HCN and N_2 were analyzed. The down fired furnace work indicated that air should be avoided in transporting reburning coal. NO reduction is lower than that obtained from the flow reactor, which implies that mixing may be an important variable in reburning. Theoretical work was focused on the reburning analysis and on the effect of delayed char nitrogen evolution on N_2O formation. The CHEMKIN code was moved to a supercomputer so that a sensitivity analysis can be conducted during the next quarter. A recent C_8 reaction mechanism has been acquired so that the mechanism can be tested against the experimental data for NO reburning with hexane. A model designed for the investigation of delayed coal (or char) nitrogen evolution on N_2O formation is also being established. 39 refs., 9 figs.

6801 (DOE/PC/88900–6) **An engineering model for coal devolatilization: Quarterly report, June 15, 1989–September 15, 1989.** Lau, Chun Wei; Niksa, S. Stanford Univ., CA (USA). High Temperature Gasdynamics Lab. Nov 1989. 32p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FG22-88PC88900. Order Number DE90004140. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

There are three distinct modeling projects in this program: (1) an expedient reaction model for coal devolatilization for large scale combustor simulators; (2) a theoretical framework to explain the behavior of different coal types; and (3) an analysis of the chemistry, heat and mass transport in the vicinity of individual coal particles, to begin to describe the initial stages of the combustion of entrained coal particles. The engineering model was developed before this program began, and has now been validated against several wire-grid studies of HVA bituminous coals. The transport analysis of devolatilizing and oxidizing coal particles, a two-component devolatilization model which resolves tar and noncondensibles was supplemented with a single heterogeneous combustion reaction at the particle surface. A transport analysis of the initial stages of pulverized coal combustion is formulated in terms of primary devolatilization, convective heat and mass transport, and heterogeneous oxidation at the particle surface. No homogeneous chemistry is included. Consequently this study aims to clarify the impact of the outward flux of volatiles on the heterogeneous ignition of individual coal particles. Primary devolatilization is represented by FLASHTWO, a recent model which predicts the yields and evolution rates of tar and a single noncondensible gaseous product, as well as the molecular weight distribution of tar. The transport analysis also includes oxygen and inert gas. Oxidation at the particle surface is described with a single nth-order global reaction, and the exotherm for CO production. 12 refs., 12 figs., 2 tabs.

6802 (DOE/PC/88912–T3) **Roles of additives and surface control in slurry atomization: Quarterly report.** Tsai, S.C. California State Univ., Long Beach, CA (USA). Dec 1989. 4p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FG22-88PC88912. Order Number DE90004020. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

This report covers two reporting periods ending in December 1989. During these periods, a model based on the classical wave mechanism for primary atomization was established, and some atomization experiments were carried out using coal water and glycerol slurries. This model gives the best least square fit to the experimental data with a coefficient of correlation greater than 0.95. This model and the preliminary results of airblast atomization of coal in glycerol and water slurries are described in this report. 1 fig., 2 tabs.

6803 (DOE/PC/88913–T1) **Mechanics/heat-transfer relation for particulate materials: Quarterly report.** Campbell, C.S. University of Southern California, Los Angeles, CA (USA). Dept. of Mechanical Engineering. Oct 1989. 13p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FG22-88PC88913. Order Number DE90004261. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This investigation attempts to explore the effect of the mechanical behavior of particle-fluid systems on their apparent thermal behavior. Three cases will be studied. The first two will examine the relationship between the particle-pressure and the heat transfer in gas and liquid fluidized beds. (Both gas and liquid fluidized beds will be studied to try and ascertain the effects of bubbling — which appears in gas-fluidized beds but is generally absent if the continuous phase is a liquid — on the particle pressure and its effects on the heat transfer.) The last will study the effective thermal conductivity of suspensions as they are sheared in a coaxial cylinder rheometer.

This quarter, we have done extensive testing of the particle pressure transducer tried to determine the length scale on which the particle pressure depends and it appears to be the bubble size, and we have been developing a new transducer that will be usable in liquid as well as gas fluidized beds. We have also built the shear cell in which we will determine the thermal conductivity of suspensions and are currently calibrating the heaters. 6 figs.

6804 (DOE/PC/88918–4) **Reduction of NO_x and SO_2 emissions from coal burning pulse combustors: Quarterly progress report, July 1, 1989–September 30, 1989.** Powell, E.A.; Zinn, B.T. Georgia Inst. of Tech., Atlanta, GA (USA). School of Aerospace Engineering. Oct 1989. 19p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FG22-88PC88918. Order Number DE90004266. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This project is concerned with the reduction of the nitrogen oxides and sulfur dioxide emissions from Rijke type pulse combustors by using combustion staging and limestone addition. This quarter about five metric tons of bituminous coal needed for the combustion experiments was obtained from Georgia Power Company, and proximate and ultimate analyses of this coal were obtained. Modifications were made on the combustor to provide for easy removal of ash, to provide a more uniform flow of air through the coal bed, and to provide an access port in the exhaust stack needed for installing the limestone injection system. The sulfur dioxide analyzer was found to be giving false readings due to a combination of sulfur contamination and moisture in the sampling system. A new element for the sample gas dryer was ordered. A series of tests of the Rijke combustor using propane fuel (without coal) was conducted. Measurements of sound pressure level, frequency, gas composition, and temperatures were made during pulsating operation over a range of fuel flow rates and air/fuel ratios. Measured carbon dioxide and oxygen concentrations were in good agreement with theoretical calculations. Nitrogen oxide concentrations ranged from 70 to 90 ppm on a zero percent oxygen basis. Finally a series of tests with coal were conducted, which established a reliable procedure for initiating pulsating combustion of the coal. In a typical test run, the coal feed rate was about 80 q/min and pulsating combustion (with amplitudes up to 160 dB) was maintained for about 15 minutes under stoichiometric conditions. 7 figs., 1 tab.

6805 (EPRI-GS–6423-Vol.2, pp. 7B.15-7B.28) **Fuel nitrogen mechanisms governing NO_x abatement for low and high rank coals.** Wendt, J.O.L. (Univ. of Arizona, Tucson (USA)); Bose, A.C.; Hein, K.R.G. Electric Power Research Inst., Palo Alto, CA (USA); Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. Jul 1989. DOE Contract AC22-84PC70771. (CONF-890318–Vol.2: Joint symposium on stationary combustion nitrogen oxide control, San Francisco, CA (USA), 6-9 Mar 1989). In *1989 symposium on stationary combustion nitrogen oxide control. Volume 2.* Order Number DE89016350. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

Fuel nitrogen mechanisms governing the efficacy of staged combustion were investigated for a low rank German Brown Coal and for a high rank Utah Bituminous Coal, burned in a downflow 2 kg/h laboratory combustor. Emphasis was on determination of the effects of coal rank on the rates of destruction of nitrogenous species in the fuel rich stage and on the subsequent conversion of these species in the burnout stage. Special experiments involving doped propane gas as a fuel allowed isolation of the dominant mechanisms in the coal runs. This research revealed that reactions destroying NO and HCN were completely controlled by known gas phase reactions, and not by heterogeneous reactions, as has been hypothesized heretofore. The overall reaction is first order in NO and in NH_3. Furthermore, the late evolution of HCN into the bulk gas phase from both coals, at long time scales, was important in driving the gas phase reactions destroying NO and other nitrogenous species.

6806 (ETDE-mf–0732477) **Reconstruction of a travelling grate firing system for utilization of fine coal with a big portion of fines. Final report.** Angleys, M.; Krampe, H.; Meyer, U. Ruhrkohle A.G., Essen (Germany, F.R.); Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). May 1989. 78p. (In German). Contract BMFT 03E-6423-A. Order Number DE90732477. Available from NTIS (US Sales Only), PC A05/MF A01.

Based on tests to burn fine coal on travelling grates with an grate covering designed for coarse coal, a special grate covering for fine coal has been developed, installed in a 16 t/h steam generator and tested. The air zone and grate seal have been improved after the first test period. Subsequently, the boiler could be run without any trouble in continuous operation at low, part and full load, whereat the portion of fines <1 mm in the fine coal attained 30 up to max. 55%. Thereby, the emissions considerably decreased the limit values according to the Clean Air Technical Code (TA Luft). Dust emission has been limited by a fabric filter. Depending on load, the SO_2-emission could be reduced for 40 to 70% by means of lime hydrate injection according to the dry additive process at Ca/S=2,5. (orig.) With 6 refs., 15 figs.

6807 (EUR–11666) **Pulverized-coal-fired, combined heat and power generating unit with central coal pulverizing: Demonstration project: Final report.** Commission of the European Communities, Luxembourg (Luxembourg). Directorate General Telecommunications, Information Industries and Innovation; IFV Power Co., Copenhagen (Denmark). c 1988. 34p. Sponsored by Commission of the European Communities. CS/092/83. Available from NTIS (US Sales Only), PC A03/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg; Price: ECU 5.

IFV Power Company (IFV) has at the Technical University of Denmark (DTH) planned and erected a small pulverized coal-fired combined heat and power generating unit. In order to obtain a remunerative operation of such a small coal-fired co-generation unit as compared with a gas or oil-fired unit, a number of new technical solutions have been introduced into the unit design. The purpose was to build a unit in all respects complying with the operating facilities of oil-fired unit. In this way it is made possible to replace oil by coal at small and medium-sized boilers. The unit has a maximum rating of 5.4 MW electricity by a simultaneous production of 11.0 MJ/s heat. The co-generation unit is unique in a number of ways: It is unmanned during normal operation and provided with with electronic equipment for monitoring and control from Kyndby Power Station (50 km away). It is pulverized coal fired in spite of its modest size. It is indirectly fired, as the pulverized coal is transported in containers from the coal pulverizers at Kyndby Power Station. Technically one year of commercial operation has proved the project to be success. Economically the decreasing gap between coal and oil prices have meant a drawback for the project. 8 figs.

6808 (EUR–11794) **Industrial burners for combustion of high-concentration water-coal slurries and respective combustion: Final technical report.** Commission of the European Communities, Luxembourg (Luxembourg). Directorate General Telecommunications, Information Industries and Innovation; Snamprogetti S.p.A., San Donato Milanese (Italy). c 1988. 78p. Sponsored by Commission of the European Communities. CS 491/84. Available from NTIS (US Sales Only), PC A05/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg ECU 7.50.

The research work on high concentration coal water mixture called REOCARB (SP's registered trademark) was started by SNAMPROGETTI in 1980 and has been continuously developed ever since. Research is carried out at three main stages: (1) laboratory research aimed at determining what are the most suitable coals, additives (fluidizing agents) and size distribution for the preparation of high solid concentration coal water mixtures that can be transported via pipeline and can be used directly as fuel for energy production; (2) construction of a pilot plant for CWM production with a capacity of 250 Kg/h of mixture. At this stage pumping tests and combustion tests are carried out with the CWM produced; and (3) technology industrialization. Results are discussed. 8 refs., 31 figs.

6809 (NEI-DK–236) **Development of equipment and methods for the measurement of gas temperature in combustion chambers.** Energiministeriets Energiforskningsprogram. Braendsler og forbraendingsteknik. Thaning, B.; Hadvig, S. Danmarks Tekniske Hoejskole, Lyngby (Denmark). Lab. for Varme- og Klimateknik. Sep 1989. 328p. (In Danish). Contract EM-1433/86-15. Order Number

DE90728080. Available from NTIS (US Sales Only), PC A15/MF A01.

EFP-86.

Possibilities for the measurement of the temperature of gas in larger combustion chambers with the help of sonic pyrometry are examined. This method is based on the relation between the speed of sound and the temperature of the gas in which the sound waves spread. The sound wave measurements were taken in a district heating system. The equipment for the determination of the speed of sound in larger combustion chambers was constructed and tested. The equipment consists of an arrangement of a high-tension spark gap which functions as the producer of sound, and a system of microphones which work as sound detectors and determines the time of transit. This whole equipment was tested in atmospheric air and in a coal-fired district heating component. A method for determining the average gas temperature and gas temperature distribution in larger combustion chambers was developed on the basis of the measured transit times. The method utilizes two dimensional fourier series for the description of the sonic speed distribution. A computer program was developed to determine the temperature distribution by measurement and was also used in a more general investigation of the feasibility of the measuring method. (AB).

6810 (ORNL/FMP–87/4, pp. 356-370) **The effects of microalloy constituents on the formation and breakdown of protective oxide scales on high-temperature alloys for use in the fossil energy industry.** Wright, I.G. (Battelle Columbus Division, OH (USA)); Colwell, J.A. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

The objectives of this research program are (1) to gain an improved understanding of the effect of alloying constituents present at low levels on the development and mode of breakdown of protective oxide scales in conditions representing those encountered in combustion and gasification processes, and (2) to achieve better control over the growth of scales which will contribute to improvements in long-term high-temperature corrosion resistance of heat exchangers and heat recovery materials. Alloys must operate in the 500 to 700C temperature range and under the most severe combustion or gasification processing environment. The approach adopted involves the evaluation of the effects of a range of elements used as minor additions to three base alloy compositions. Effects of these additions on the development of protective scales will be assessed through comparison with the corrosion kinetics and scale morphologies of the base alloys developed in exposures in specific gas mixtures. Limited comparisons will be made of initial stages of scale development on the base alloys, and of the effects of some of the minor additions, using an Auger electron spectroscopy/X-ray photo electron spectroscopy (AEX/XPS) analytical chamber equipped with a scanning electron microscope. The surface composition and chemical bonding in the scales will be monitored as a function of time in a constant gaseous environment. Experiments are also planned to provide links with the more conventional thermo-balance studies, to ensure the validity of these in situ studies. Base alloys chosen contain 25 percent by weight of chromium to ensure continuous, protective scales of Cr_2O_3 are reliably formed. A literature survey covered the past 10 years.

6811 (ORNL/FMP–87/4, pp. 371-383) **Investigation of the effects of microalloy constituents, surface treatment and oxidation conditions on the development and breakdown of protective oxide scales.** Vedula (Case Western Reserve Univ., Cleveland, OH (USA)); , K.; Michal, G.M.; Michell, T.E.; Welsch, G.; Grobis, I.; Chang, S. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

The initial results of a program designed to define the factors that effect the protectiveness of oxide scales formed in mixed S_2O_2 atmosphere environments are presented. Scale formations on Fe-25Cr and Fe-25Cr-20Ni alloys which are chromia formers and an Fe-25Cr-6Al alloy which is an alumina former have been determined at 700°C under an SO_2 atmosphere. These preliminary results indicate the alumina forming alloy is superior to the chromia forming alloy under the conditions examined. An analysis of the thermodynamic activities of the major constituents of the three alloys has been conducted, and oxide/sulfied stability diagrams for the elements Fe, Cr, Ni and Al at these activity levels have been constructed.

6812 (ORNL/TM–11379) **Evaluation of freeboard performance in a fluidized bed combustor: Final report.** Krishnan, R.P. (Oak Ridge National Lab., TN (USA)); Anthony, J.; Chandrasekhar, S.; Murthy, A.V.; Rajaram, S.; Rao, A.V.J.; Rajavel, M.; Srinivasan, S. Oak Ridge National Lab., TN (USA). Dec 1989. 134p. Sponsored by U.S. Agency for International Development. DOE Contract AC05-84OR21400. Order Number DE90004391. Available from NTIS, PC A07/MF A01 - OSTI; GPO Dep.

Under a cooperative agreement between the US Agency for International Development (USAID) and the Government of India (GOI), a joint research project in fluidized bed combustion (FBC) was carried out by the Bharat Heavy Electricals Ltd. (BHEL), India, and the Oak Ridge National Laboratory (ORNL). The project was aimed at obtaining basic engineering data on the combustion of high-ash Indian coals (up to 45% ash), and coal washery rejects (up to 70% ash). Quantitative measurements of overall combustion efficiency, in-bed and freeboard combustion, in-bed heat transfer coefficient, freeboard heat transfer coefficient, flue gas composition and temperature profiles in the bed and freeboard were of particular interest. A 1 m x 1 m cross section, 11.0-m high, refractory-lined FBC was erected at BHEL, Trichy. The combustor was designed as a hot water generator with a capacity of 90 t/h at 10 kg/cm^2 and 179°C. Tests were conducted on a sub-bituminous Indian coal (~38% ash) and a coal washery reject (65% ash), with and without flyash reinjection. Both underbed and overbed fuel feeding modes were tested in the facility. Three series of long-duration tests typically lasting 40 to 50 h were conducted in the facility for a total of 600 h after about 300 h of shakedown testing. Operational problems associated with underbed/overbed feeding, flyash reinjection and ash removal were identified. 26 refs., 44 figs., 1 tab.

6813 (STEV-FBT–89-46) **Hydration as a means of improving the sorbent utilization in pressurized fluidized bed combustion.** Jaeglid, U. (Chalmers Univ. of Tech., Goeteborg (SE). Dept. of Inorganic Chemistry); Ljungstroem, E. Statens Energiverk, Stockholm (Sweden); Chalmers Univ. of Tech., Goeteborg (Sweden). Dept. of Inorganic Chemistry. 1989. 19p. Project STEV-276-363. (CTH-OOK–89-07). Order Number DE90728289. Available from NTIS (US Sales Only), PC A03/MF A01.

Bed ash samples and cyclone ash samples from a PFBC unit have been treated with water in different ways and then calcined. The cyclone ash was also calcined, water-treated and again calcined. The reason for the trials was to increase the sulphur capacity of the absorbent residues in the ashes. Direct water treatment of waste material from the PFBC process does not improve the sulphur capacity, compared to untreated material. This is due to the un-reacted calcium being present as $CaCO_3$ rather than CaO in the waste. When the material was pre-calcined before the water treatment an increase in sulphur capacity was noted. The magnitude of this effect was small. Due to the preliminary results obtained in this investigation it was not considered fruitful to continue work involving hydration of PFBC waste material and the investigation was closed. 5 illus., 3 tabs.

6814 (VTT-TUTK–636) **Emissions and development of combustion and handling technology at peat five power plant.** Miettinen, M. (Valtion Teknillinen Tutkimuskeskus, Jyvaeskylae (Finland). Polttoaine- ja Polttotekniikan Lab.); Paakkinen, K.; Impola, R.; Heiskanen, V.P.; Vesterinen, R.; Huotari, J. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). Aug 1989. 111p. (In Finnish). Order Number DE90728180. Available from NTIS (US Sales Only), PC A06/MF A01.

The aim of the study was to develop more economical peat and coal handling and combustion technology, and to increase the knowledge of the environmental effects of using peat and coal. Combustion tests were carried out at the Rauhalahti 265 MW_{th} peat and coal fired power plant and fundamental correlations between

moisture content, particle size, burn out and heat transfer were determined at the Skoeldvik combustion test rig.

6815 Dynamics of coal-derived fuel droplets in combustor. Sitarski, M. (Clarkson Univ., c/o U.S. Dept. of Energy, Morgantown Energy Technology Center, Morgantown, WV (US)). vp of The 8th Miami international conference on alternative energy sources. Volume 1-2 (Condensed Papers). Vezioglu, T.N. Clean Energy Research Inst. University of Miami, Coral Gables, FL (1988). (CONF-871204–: 8. Miami international conference on alternative energy sources, Miami Beach, FL (USA), 14-16 Dec 1987).

The use of coal-derived-fuels (coal-water, coal-methanol, coal-oil slurries) for direct firing in heat engines has to meet a number of technological requirements. Among the most important ones is the short burn-out time of the fuel particles (ensuring efficient combustion) and small size of the residual ash particles (eroding vital surfaces of the heat engines). The studied process of secondary atomization of the fuel droplets inside combustor is very beneficial to the fulfillment of the both requirements. Feasibility of the secondary atomization results from dynamics of the fuel droplets in combustor during the first few milliseconds when the process of intense evaporation of the liquid takes place. Necessary conditions for disruptive boiling of the coal-derived fuel droplets are estimated by the Monte Carlo simulation of the developed theoretical model. The computations are carried out for coal-water and coal-methanol slurry droplets at conditions corresponding to those in combustors of gas turbines. It is concluded from the results of the computations that the droplets have to be preheated during primary atomization to temperature close to the boiling temperature of the liquid and exposed to high temperature thermal radiation.

6816 Physical and chemical transformations during pulverized coal combustion – optical systems for measurements. Ottesen, D.K. (Sandia National Laboratories, Livermore, CA (USA)); Hardesty, D.R.; Radziemski, L.J. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 81-90 (1988). (CONF-8806316–: Ash chemistry of coal, Toronto (Canada), 5-10 Jun 1988).

One of the most difficult problems in developing diagnostic methods for coal combustion research is that of determining the composition of entrained coal, char, and mineral matter particles in the combustion zone. The authors have employed two laser-based techniques for the simultaneous measurement of the size, velocity, and elemental composition of particles in combustion flows. Laser spark spectroscopy, also called laser induced breakdown spectroscopy (LIBS), is used to determine the elemental composition of coal particles. Sizing measurements are done using two-color laser light scattering. Laser spark spectroscopy is a variation of conventional emission spectroscopy which uses a focused pulsed laser beam to generate an optical breakdown, commonly called a laser spark or a laser induced plasma. The origin and uses of this technique are well summarized. Many of its properties are similar to those of conventional arc or spark plasmas as discussed in standard texts on spectrochemistry. As with conventional techniques, the laser spark allows simultaneous multi-element detection. An important advantage is the ability to obtain information in hostile environments, in situ, where electrodes cannot be introduced. Two principal applications for this technique are proposed. The first is the simultaneous measurement of size, velocity, and composition of single particles and is primarily an analytical research tool for coal combustion studies. The second is the measurement of bulk properties before, during, and after combustion by coaddition of hundreds or thousands of individual spectra. This can be envisioned as an on-line monitor in an operating combustor. The experiments have elucidated the advantages and difficulties which will be encountered in these applications.

6817 Fundamental modeling of pulverized coal and coal-water slurry combustion in a gas turbine combustor. Chatwani, A. (Avco Research Laboratory, Inc., Everett, MA (USA)); Turan, A.; Hals, F. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 165-175 (1988). (CONF-8806317–: Mathematical simulation of coal conversion processes, Toronto (Canada), 5-10 Jun 1988).

This work describes the essential features of a coal combustion model which is incorporated into a three-dimensional, steady-state, two-phase, turbulent, reactive flow code. The code is a modified and advanced version of INTERN code originally developed at Imperial College which has gone through many stages of development and validation. Swithenbank et al have reported spray combustion model results for an experimental can combustor. The code has since then been modified by and made public under a US Army program. A number of code modifications and improvements have been made at ARL. The earlier version of code was written for a small CDC machine which relied on frequent disk/memory transfer and overlay features to carry the computations resulting in loss of computational speed. These limitations have now been removed. For spray applications, the fuel droplet vaporization generates gaseous fuel of uniform composition; hence the earlier formulation relied upon the use of conserved scalar approximation to reduce the number of species equations to be solved. In applications related to coal fuel, coal pyrolysis leads to the formation of at least two different gaseous fuels and a solid fuel of different composition. The authors have therefore removed the conserved scalar formulation for the sake of generality and easy adaptability to complex fuel situations.

6818 Modeling of agglomeration in a fluidized bed. Rehmat, A. (Institute of Gas Technology, Chicago, IL (USA)); Huang, C.; Carty, R.; Hariri, H.; Arastoopour, H. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 176-187 (1988). (CONF-8806317–: Mathematical simulation of coal conversion processes, Toronto (Canada), 5-10 Jun 1988).

A fluidized bed containing a central jet was operated with low-temperature melting materials to obtain the rate of agglomeration as well as to measure the temperature distribution within the fluidized bed. The rate of agglomeration was obtained as a function of operating parameters such as temperature and velocity. The agglomeration rate defined, as the rate of change in the number of particles of a particular size, was determined from the particle population balance using the experimental data. The agglomeration model developed to predict the agglomeration rate constant based on the temperature distribution in the fluidized bed and the rate of entrainment of particles into the jet yielded values for the rate constants similar to the experimental values.

6819 Flowfield simulations in industrial furnace configurations. Gillis, P.A. (Brigham Young Univ., Provo, UT (USA)); Smith, P.J. *Preprints of Papers, American Chemical Society, Division of Fuel Chemistry (USA),* 33(2): 215-222 (1988). (CONF-8806317–: Mathematical simulation of coal conversion processes, Toronto (Canada), 5-10 Jun 1988).

A fundamental element of comprehensive pulverized-fuel combustion modeling is the description of the turbulent gaseous flow field within the furnace. As part of a program to develop a three-dimensional coal combustion code, a non-reacting gas flow dynamics model has been developed. This flow model, GAS3D, has been demonstrated in a variety of industrial configurations including corner-fired, cross-fired, and wall-fired furnace geometries. This paper discusses the components and capabilities of the model and presents comparisons between experimental data and model predictions for a wall-fired furnace. The emphasis of this paper is on evaluating model performance. Experimental data has been obtained from Consolidation Coal Company for a wall-fired furnace. This configuration has been simulated with GAS3D using three different turbulence models. A description of the flow patterns predicted within the furnace are given. Comparisons are made between the predictions and experimental data and between the different turbulence models.

0150 Economic, Industrial, and Business Aspects

Refer also to citation(s) 6677, 6773, 7862

6820 (CMRC–8902, pp. 1-34) **Policy to increase coal utilization when oil prices are low.** Tani, Shigeo (Agency of Natural Resources and Energy, Tokyo, Japan). Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

A study was made in order to increase coal in utilization. Japan depends upon the importation in 80% of supply of the primary energy. As Middle East, its major supplier is unstable in politics, it is particularly important to fortify the energy in structure of supply and demand. The recent wandering lowness in oil price makes it particularly indispensable to put the utilization technology, through heightening coal in cleanness and convenience, to practical use, and take other measures, in order to amplify coal in demand. In Japan, conventional demand of coal has been mainly made by the electric power and cement industries, and hardly increases for the time being. Therefore, new measures to convert heavy oil to coal are necessary in the paper making, pulp, chemical and other industries, in which major boilers are presently entering the renewal period. Coal's dirty image is being amortized by the improved handling technology under slurry, powder and other forms. As the coal introduction to the general industry is being attenuated in restraining factors, a proposal was made to increase the coal demand. 3 refs., 8 figs., 12 tabs.

6821 (LA-UR–86-2600, pp. 77-85) **The Costa Rican peat project.** Thayer, G.R.; Williamson, K.D.; Cohen, A.D. Los Alamos National Lab., NM (USA). Fal 1986. In *Los Alamos science, Number 14*. Order Number DE87003612. Available from NTIS, PC A06/MF A01.

Scientists from the Laboratory and Refinadora Costarricense de Petroleo (RECOPE) are working together to assess the development potential of peat, an indigenous, unused resource in Costa Rica. This carbon-rich organic sediment, produced in swaps and marches from partially decayed organic matter, could become a significant asset in a number of different ways. If made into briquettes and used as a fuel for heating and cooking, it could help reduce the heavy dependence on fuel wood, which now supplies 50 percent of Costa Rica's energy. If used to fuel electric power plants, it could help reduce oil imports. Since harvesting of peat is a labor-intensive operation, its development would provide jobs for the people in the area where it is found. Further, its availability as a fuel might bring industries to those area. Eventually peat might become the basis of high-tech industries converting this resource into liquid and gaseous fuels of valuable organic chemicals such as waxes, resins, and medicinals. The environmental impact of peat harvesting and the economics of various end uses are also being examined.

0160 Health and Safety

Refer also to citation(s) 6774

6822 (CRIEPI-U–88057) **Lung clearance of inhaled coal fly ash particles and morphological changes of respiratory organs.** Negishi, T. (and others). Central Research Inst. of Electric Power Industry, Tokyo (Japan). 1989. vp. (In Japanese).

The study investigates the particle clearance from the lung and morphological changes of respiratory organs in the recovery period after long-term exposure to coal fly ash. The experiment was carried out on hamsters.

0170 Legislation and Regulations

6823 (NBNRE–89-6) **New Brunswick Crown peat resource management policy 1988.** New Brunswick Dept. of Natural Resources and Energy, Fredericton, NB (Canada). Minerals and Energy Div. 1989. 27p. (MICROLOG–89-04147). Available from PC New Brunswick Dept. of Natural Resources and Energy, P.O. Box 6000, Fredericton, NB, CAN E3B 5H1; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $2.00 CAN; MF $10 CAN.

In the Province of New Brunswick, peat and peat moss are defined as quarriable substances and, thus, are dealt with under the Quarriable Substances Act. The rights to peat and peat moss are therefore vested in the owner of the land on which they lie. This Management Policy report deals only with peat and peat moss situated on Crown lands. It discusses the historical background of peat exploitation in New Brunswick, the objectives of the Government's policy on this subject, and the conditions to be satisfied for the acquisition of the right to extract peat on Crown lands: quarry application form, peat exploration licence, and peat lease (terms of the lease, size, security deposit, rentals and royalties). New Brunswick regulation 88-188 under the Quarriable Substances Act is included in an appendix to the report. 1 ref., 2 figs.

02 PETROLEUM

Refer also to citation(s) 6929

6824 (CIM/S–CE-02846) **Third Saskatchewan petroleum conference.** Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. vp. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

This conference deals with the enhanced recovery of light and heavy oil, with the petroleum industry, and with some economic aspects of petroleum. The majority of the papers deal with core-flooding experiments, calculations and field tests in order to optimize the recovery of light oil, heavy oil, or bitumens through waterflooding, steam flooding, steam plus air injection, steam plus foam injection, and injection of carbon dioxide, carbon dioxide plus solution of caustic in water, or carbon dioxide plus ethane. Several papers deal with directional drilling and horizontal wells. Particular papers deal with the use of computer-aided tomography for core study, with the scouring and cementing of wells, the resistance of proppants in the presence of steam, and the extraction of surfactants from the emulsion produced. The conference also deals with the petroleum industry in general: new oil reservoirs in Saskatchewan, upgrading of heavy oil and bitumens, and flow of oil/water emulsions in pipelines. Economic aspects include the future of the petroleum and gas markets, contract research at the Saskatachewan Research Council, the end of the monopoly of SaskPower for the sales of natural gas in Saskatchewan, and the consolidation of batteries of wells in order to reduce the operating costs. Separate abstracts have been prepared for 31 papers.

6825 (CPA–CE-02812) **Managing transition on the Canadian petroleum frontiers.** Canadian Petroleum Association, Calgary, AB (Canada). 1988. 391p. (CONF-8805349–: 15. CPA (Canadian Petroleum Association) Frontier Division workshop, Fairmont (Canada), 8-11 May 1988; CE–02812). Available from PC Infopall, Pallister Resource Management, Bay 105, 4116 - 64th. Ave., S.E., Calgary, AB, CAN T2C 2B3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $24.00 CAN; MF $10 CAN.

This workshop covers the regulatory regimes that support the Canada Petroleum Resources Act and the Oil and Gas Production and Conservation Act with perspectives from different parts of Canada; the economic and fiscal realities of frontier developments; technical and environmental research issues; production systems under consideration on Canada Lands; and a review of the socio-environmental challenges. The workshop concluded with a summary and comments from representatives of the industry, the environmental administration banking, and the federal regulatory administration. A list of participants is included. Abstracts are given for each of the 8 sessions.

6826 (CPA–CE-02812, pp. 125-136) **Role of non-profit organizations.** Robinson, M. (Arctic Inst. of North America); Adams, P.; Clark, J. Canadian Petroleum Association, Calgary, AB (Canada). 1988. (CONF-8805349–: 15. CPA (Canadian Petroleum Association) Frontier Division workshop, Fairmont (Canada), 8-11 May 1988; CE–02812). In *Managing transition on the Canadian petroleum frontiers*. Available from PC Infopall, Pallister Resource Management, Bay 105, 4116 - 64th. Ave., S.E., Calgary, AB, CAN T2C 2B3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $24.00 CAN; MF $10 CAN.

This panel presentation reviews the activities and roles of 3 non-profit research organizations. The first presentation describes the Arctic Institute of North America (AINA) and its establishment, and the later introduction of the Northern Information Homecoming Mission, dedicated to creating practical information networks and

supplying northern decision makers with critically analyzed information in areas of immediate demand. A description of the Mission's work is given, including networking, the creation of the Arctic Science and Technology Information System database, and research facilities and publications. The second presentation describes the Centre for Frontier Engineering Research (C-FER), its organization, and its projects, including highlights. The third presentation describes the Centre for Cold Ocean Resources Engineering (C-CORE), its mandate, organization and responsibilities, and highlights of its research activities.

6827 (CPA–CE-02812, pp. 105-124) **Research and development.** Robertson, M. (Petro-Canada (Canada)); Stagg, J.; Cook, B. Canadian Petroleum Association, Calgary, AB (Canada). 1988. (CONF-8805349–: 15. CPA (Canadian Petroleum Association) Frontier Division workshop, Fairmont (Canada), 8-11 May 1988; CE–02812). In *Managing transition on the Canadian petroleum frontiers.* Available from PC Infopall, Pallister Resource Management, Bay 105, 4116 - 64th. Ave., S.E., Calgary, AB, CAN T2C 2B3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $24.00 CAN; MF $10 CAN.

This panel presentation covers research and development in the frontier areas. The first presentation describes the Environmental Studies Research Fund, which became operational in 1983 and which conducts national or regional studies. The background to the establishment of the Fund is described, then the functions and operations, and projects funded. The second presentation describes the Northern Oil and Gas Action Program a 7-year (1984-91) federal/territorial preparedness program. Descriptions are given of the objectives, organization, participants, delivery, program achievements, current status, priorities for the next phase, an industry involvment. The third presentation covers the energy research and development program of the Government of Canada, including its organization, its activities in the petroleum sector, and highlights. Comparisons are made between the 3 programs. 11 figs.

6828 (NEI-NO–100) **Norwegian oil and gas in a low-price market.** Norges Teknisk-Naturvitenskapelige Forskningsraad, Oslo (Norway). 1989. 263p. (CONF-8906258–: 1989 NTNF oil and gas conference, Oslo (Norway), 13-14 Jun 1989). Order Number DE90728220. Available from NTIS (US Sales Only), PC A12/MF A01.

The conference proceedings contain 16 papers. The topics covered are: Cost reduction through improved technology; From USD18 to USD10 technology; Decreasing production costs by optimizing field operations; Subsea installations - reduced production costs compared with fixed platform installations; Efficient operations and maintenance of platforms in the North Sea; Platform manning levels in the North Sea, can they be reduced; Productivity and work environment; An analysis of offshore development cost differences between the UK and Norwegian sectors of the North sea; Challenge to Norway as a gas-producing nation after the year 2000; Market challenge for gas policy compared to oil; Industrial challenge by use of natural gas in Norway; National objectives for research and development offshore; NTNF's research and development programs in offshore technology; Views on the State research and development Program for Utilization of Natural Gas (SPUNG); Chemical research and natural gas exploitation; Fractals - new concepts for reservoir engineering. Separate abstracts were prepared for four of the papers.

6829 (PCCIM–CE-02786-2.vols) **Building on 40 years of achievement: Volumes 1 and 2.** Petroleum Society of CIM (Canada). 1989. vp. (CONF-8905249–: 40. annual technical meeting of the Petroleum Society of the Canadian Institute of Mining and Metallurgy (CIM), Banff (Canada), 28-31 May 1989; CE–02786). Available from Petroleum Society of the CIM, c/o AMOCO Canada, Box 200, Calgary, AB, CAN T2P 0H8. Prices: $80.00 CAN.

Major topics covered in this conference on heavy oil and tar sands include: well drilling and completion; well testing methods; well simulation; recovery processes, especially enhanced recovery processes, ore flow phenomena; processing of heavy oils and tarsands; reservoir engineering, computer applications in field operations, formulation evaluation; formation fracturing and stimulation; and the economics of the petroleum industry. Special sessions were held on management and marketing aspects of the industry and on nomenclature and definitions related to petroleum resources. Separate abstracts have been prepared for 93 papers from this conference.

0202 Reserves, Geology, and Exploration

Refer also to citation(s) 6833, 6837, 6842, 6865, 6930, 8603

6830 (AOSTRA–CE-02657, pp. 64) **Resources to heavy oil and natural bitumen worldwide.** Meyer, R.F. (US Geological Survey, Reston, VA (USA)); Duford, J.M. Alberta Oil Sands Technology and Research Authority, Edmonton, AB (Canada). 1988. (CONF-880807–: 4. UNITAR/UNDP international conference on heavy crude and tar sands, Edmonton (Canada), 7-12 Aug 1988; CE–02657). In *UNITAR/UNDP 4th international conference on heavy crude and tar sands, vol. 6.* Available from Alberta Oil Sands Technology and Research Authority, 500 Highfield Pl., 10010-106 St., Edmonton, AB, CAN T5J 3L8. Prices: $150.00 CAN.

Data gathered worldwide on production and resources of heavy crude oil and bitumen are compiled and analyzed. For the United States and Canada data were supplied from Dwight's PDS Service. For the rest of the world, data were derived from the Petroconsultants oil and gas field file and the literature. Retrieval was based on an American Petroleum Institute gravity cutoff of 20°. About 30% of the fields surveyed were eliminated because they had no gravity data. These fields are mostly small and are believed to produce lighter oils. The aggregated information was compiled by geological basin. Data are summarized in tables by continent and further tabulated by geographical province. 1985 production figures for heavy oil are included. The resources of heavy oil and natural bitumen in the world are very large. World heavy crude oil production is currently estimated to be 2.3 billion barrels per year. Original reserves in known fields are estimated to be 261 billion barrels. Undiscovered resources are expected to add another 401 billion barrels. Natural bitumen in place amounts to about 2,502 billion barrels of demonstrated resource and nearly 865 billion barrels of inferred resource in 63 provinces. Present production is 126 million barrels per year, all from western Canada. If only 15% of total known bitumen resources were recoverable, it would mean availability of 375 billion barrels of oil, equivalent to the original crude reserves in Saudi Arabia, Kuwait, and Iraq combined. To this may be added 130 billion barrels of inferred recoverable natural bitumen from undiscovered sources. 54 refs., 5 figs., 11 tabs.

6831 (CIM/S–CE-02846, pp. 18) **Reservoir geology of the S.W. Midale Pool southeast Saskatchewan.** Schneberger, K.M. (Saskatchewan Oil and Gas Corp., SK (Canada)). Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

Delineation and development drilling of the Midale pool in Saskatchewan from 1956 to 1985, resulted in a total of 42 wells, 31 of which were cased as potential Midale oil wells. The Midale Marly member is responsible for approximately 75% of the production from the 31 oil wells developed in the Southwest Midale pool. The remaining 25% is attributed to the Midale Vuggy and Frobisher Halbrite members. To date, this pool has produced in excess of 400,000 m^3 of medium gravity crude oil on primary production. Unique diagenetic events affecting the Marly and Vuggy reservoir lithofacies have either developed reservoir (i.e. Vuggy vadose zone solutioning, Marly dolomitization), or destroyed reservoir (i.e. Vuggy sparry calcite/anhydrite cementation, incomplete Marly dolomitization). The understanding of the depositional and diagenetic characteristics of the Midale Beds within the pool resulted in the following conclusions: that lateral continuity and relative homogeneity of the Marly dolomite reservoir facies (plus the general excellent quality and thickness of this reservoir in the areas of production) suggests that the Marly will be an excellent candidate for a waterflood scheme, that lateral discontinuity and heterogeneity of the Vuggy packstone/grainstone reservoir facies (in addition to general

poorer quality reservoir development) suggests that the Vuggy will be prone to selective and limited waterflood applicable to localized areas, and finally that negligible reservoir communication between the Marly and Vuggy members is anticipated, since the development of a laterally continuous and impermeable black, carbonaceous lime mudstone near the top of the Vuggy member acts as a vertical permeability barrier. 10 refs., 24 figs

6832 (Juel–2307) **Migration and accumulation history of petroleum from the northern upper Rhine valley and its relation to the diagnosis of clastic source rocks.** Rueckheim, J. Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Inst. fuer Chemie 5 - Erdoel und Organische Geochemie; Technische Hochschule Aachen (Germany, F.R.). Aug 1989. 294p. (In German). Order Number DE90732538. Available from NTIS (US Sales Only), PC A13/MF A01.

Based on an interdisciplinary research program, i.e. the application of both organic-geochemical and petrographic methods, this thesis was intended to elucidate the migration- and accumulation history of petroleum in the Northern Rhinegraben, and its relationship to sandstone diagenesis. Geochemical analyses of the reservoired oils revealed considerable variations in the oil composition within the Echo/Tangosierra oilfield. These include variations in gross composition, n-alkane distribution and molecular maturity. The compositional heterogeneities change systematically with the petrophysical properties of the reservoir rocks, e.g. lower maturity oils are restricted to low porosity/permeability intervals and vice versa. Kinetic models for both hydrocarbon generation and kerogen maturation in the source rocks were used to reconstruct the accumulation history of the Echo/Tangosierra oilfield. To explain the variations in oil composition an accumulation model is proposed. Petrographic and geochemical analyses of the reservoir sandstones have been applied to reconstruct the diagenetic history of the reservoir rocks. By integrating the results of the different methods applied in this study (geochemistry/petrophysics/petrography), it was possible to relate the history of hydrocarbon generation and kerogen maturation to the diagenetic evolution of the reservoir rocks. (orig./RB).

0203 Drilling and Production

Refer also to citation(s) 6830, 6886, 6941, 8190

6833 (AOSTRA–CE-02657, pp. 11) **Development of the peacock hydraulic pump jack for Canadian heavy oil production.** Emo, B.P. (Peacock, Inc., Edmonton, AB (Canada)); Erismann, G.; Hruschak, P. Alberta Oil Sands Technology and Research Authority, Edmonton, AB (Canada). 1988. (CONF-880807–: 4. UNITAR/UNDP international conference on heavy crude and tar sands, Edmonton (Canada), 7-12 Aug 1988; CE–02657). In *UNITAR/UNDP 4th international conference on heavy crude and tar sands, vol. 6.* Available from Alberta Oil Sands Technology and Research Authority, 500 Highfield Pl., 10010-106 St., Edmonton, AB, CAN T5J 3L8. Prices: $150.00 CAN.

Nearly all of the production of heavy oil in Alberta and Saskatchewan employs rod actuated downhole pumps. The traditional walking beam pump is not well suited for heavy oil pumping. Major problems encountered with rod actuated pumps include the following. Slow rod fall in the viscous liquid causes very slow pumping speed that lowers production rates. The slow pumping speeds in turn lead to pump drive failures. Changing well conditions such as water cut, temperature, and viscosity, make proper setting of the geared pump drive difficult. A new hydraulic pump designed to respond to these problems is described. The hydraulic pump jack offers the distinct advantage of independent control of upstroke and downstroke speed that can be performed in a smooth non-shocking cushioned drive arrangement. Furthermore, the pumping rate can be easily adjusted to suit well conditions. The solutions to problems encountered with the new design are described. 3 refs., 11 figs., 1 tab.

6834 (AOSTRA–CE-02657, pp. 19) **The in-situ combustion industrial exploitation of Suplacu de Barcau Panonion Field. The socialist republic of Romania.** Aldea, G.H. (Inst. de Cercetari oi Proiectari Petrol si Gaze, Cimpina (Romania)); Turta, A.L.; Zamfir, M. Alberta Oil Sands Technology and Research Authority, Edmonton, AB (Canada). 1988. (CONF-880807–: 4. UNITAR/UNDP international conference on heavy crude and tar sands, Edmonton (Canada), 7-12 Aug 1988; CE–02657). In *UNITAR/UNDP 4th international conference on heavy crude and tar sands, vol. 6.* Available from Alberta Oil Sands Technology and Research Authority, 500 Highfield Pl., 10010-106 St., Edmonton, AB, CAN T5J 3L8. Prices: $150.00 CAN.

The Suplacu de Barcau oil field in Rumania is a shallow field containing a very heavy oil. Exploitation of the field via in-situ combustion began in 1971. There are now 120 combustion wells and 600 production wells in operation. The combustion process is developed from the top to the bottom of the field on a 7.5 km long combustion front. Oil recovery in the combustion front area is more than 50% as against 9% calculated with primary recovery. The average oil production rate is 2.5-3 tonnes/d/well. The pay layer is made up of unconsolidated sands. Special constructions are used to control sand inflow. The crude oil is produced in the form of a stable emulsion of poorly mineralized water in oil. The production, collection, dehydration, and desalting of these emulsions causes great difficulties. Liquid and solid fluidizers are admininstered to the bottom hole or injected into the formation to minimize those problems. The geology of the field is described. 13 refs., 2 tabs.

6835 (AOSTRA–CE-02657, pp. 28) **An innovative system for gravity independent drilling.** Rodland, A. (Norwegian Inst. of Technology, Tronheim (Norway)); Dahl-Jorgensen, E.; Hiorth, E.; Tanberg, G. Alberta Oil Sands Technology and Research Authority, Edmonton, AB (Canada). 1988. (CONF-880807–: 4. UNITAR/UNDP international conference on heavy crude and tar sands, Edmonton (Canada), 7-12 Aug 1988; CE–02657). In *UNITAR/UNDP 4th international conference on heavy crude and tar sands, vol. 6.* Available from Alberta Oil Sands Technology and Research Authority, 500 Highfield Pl., 10010-106 St., Edmonton, AB, CAN T5J 3L8. Prices: $150.00 CAN.

Norwegian continental shelf oil deposits are characterized by thin oil zones and small oil deposits that are primarily two dimensional. The KOLIBOMAC (continuous lining boring machine) project is an effort to develop drilling equipment that will permit these deposits to be expoited in an energy efficient way. The program initially focused on developing a borehole liner module and lining material that could be mixed and cast in place around an inside sliding form. The form is designed to facilitate the downhole mixing of components and injection of mixed material into the annulus surrounding the module. The unit is designed to completely control the space into which the material is injected. The liner has some flexibility in the size of the borehole it forms. The goal in materials development was to produce injectable liner materials that could replace steel borehole casings. A number of materials were tested. The material selected is a polymer made from five or six components. Its flexural strength right after casting is 8-9 M pascals. After 1 1/2 years at 90°C, the material has a flexural strength of about 4 M pascals. The drilling unit is also to be equipped with a drilling assembly capable of gravity independent drilling forward or backward. It is expected that existing equipment will be used. A computerized downhole information sampling unit has been developed. This part of the project is now being expanded to include full drift and azimuth steering capabilities. A project to develop an angular steering unit that can be steered on commands from the navigation unit is underway. The design of a drill bit that can be inserted and withdrawn through a drill hole that is smaller in diameter than the bit is near completion. Copies of slides used in this presentation are included. 4 refs., 3 tabs., 18 figs.

6836 (AUC-IBT-R–8906) **Shape optimization of mono-tower offshore platform.** Structural Reliability Theory. Paper, 53. Enevoldsen, I.; Soerensen, J.D.; Thoft-Christensen, P. Aalborg Universitetscenter (Denmark). Inst. for Bygningsteknik. Mar 1989. 14p. Order Number DE90728128. Available from NTIS (US Sales Only), PC A03/MF A01.

Reliability-based shape optimization of mono-tower platforms is considered. As design variables sizing and shape variables are used. The design variables are divided into integer and real-valued optimization variables. Effective optimization procedures to solve the reliability- based shape optimization problem are presented. An exampel is also presented. (author).

6837 (AUC-IBT-R–8909) **Some aspects of reliability of offshore structures.** Structural Reliability Theory. Paper, 55. Sigurdsson, G. Aalborg Universitetscenter (Denmark). Inst. for Bygningsteknik. Jun 1989. 122p. Order Number DE90728129. Available from NTIS (US Sales Only), PC A06/MF A01.

The use of modern structural reliability theory for modelling uncertainties in offshore engineering has gained widespread support. The uncertainties may relate to both physical quantities, e.g. material quantities and loads, and uncertainties in the mathematical modelling of the structural system. Most systems reliability methods are based on the concept of failure elements. The following examples of failure elements used in structural systems reliability theory are discussed, tension/compression failur elements (yielding), bending failure elements (yielding), combined load effect failure elements (yielding), strain softening failure elements, instability failure elements, buckling failure elements, global instability failure elements, fatigue failure elements, punching failure elements and slab failure elements. The scope of this thesis is the development of some applicable methods for evaluating the reliability of offshore structures. Two different definitions of system failure modes are used, namely a failure mode due to formation of a mechanism (collapse), and a failure mode due to fatigue failure. An applicable method for evaluating the reliability of jacket type offshore structures with respect to plastic collapse is presented. A method for evaluating the reliability of jacket type offshore structures with respect to fatigue failure, when a single failure element fails is given. A probabilistic model of the sea states is considered, where for a short-term period (a few hours) the sea surface is assumed to be a zero-mean ergodic Gaussian process. A probabilistic modelling of the wave loading is given. Morison's equation is applied to estimate the force on the structural elements, and structural response in considered. A stochastic modelling of fatigue failures is described. (AB).

6838 (CIM/S–CE-02846, pp. 9) **Application of horizontal wells in the Midale unit.** Beliveau, D. (Shell Canada Ltd. (Canada)). Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

The application of horizontal wells is one of the most rapidly growing areas of petroleum engineering technology today. Typically, horizontal wells are applied in problem producing areas such as fractured reservoirs, heavy oils, tight rocks, thin formations, or coning/cusping situations. The Midale field is part of a Mississippian carbonate trend in southeastern Saskatchewan. The Midale reservoir contains many natural vertical fractures, which are oriented predominantly in a NE-SW direction. The fracture spacing varies from several inches to a few feet. The oriented fracture system creates a permeability anisotropy which averages about 25:1 fieldwide. Based on available data, the Midale field appears to be an excellent candidate for horizontal well drilling. Horizontal wells can be positioned to intersect a large number of vertical fractures, which should result in an increase of about 10 times in oil production. Three horizontal wells will be drilled in the Midale Unit in 1989. This paper describes the planning of three wells. 6 refs., 6 figs.

6839 (CIM/S–CE-02846, pp. 19) **A Dodsland-Hoosier Viking field waterflood prediction.** Carlson, M.R. (Scientific Software-Intercomp); Andrews, R.J. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

A waterflood prediction study has been developed for the Dodsland Viking field in Saskatchewan, Canada. This study demonstrates the importance of the geological description used to account for fieldwide variations in pressure-volume-temperature properties. The methodology identifies the significance of local wellbore effects (hydraulic fracture stimulations). The increased power of SimBest II, which is fully implicit and uses an improved matrix solver, ESPIDO, enables one to model this problem where as older technology fails (Beta ii). Finally, the results are compared against actual offset production performance and models which do not account for local wellbore effects. 23 refs., 15 figs., 3 tabs.

6840 (CIM/S–CE-02846, pp. 9) **Application of scouring theory to drilling particles removal.** Bizanti, M.S. (Lousiana Tech Univ., LA (USA)). Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

Efficient bottomhole cleaning has been shown to significantly contribute to the increase in recovered oil in place. A detailed investigation into cutting dislodgment and movement may give insight on how to increase the bottomhole cleaning ability of a well. This cleaning ability can be predicted by the use of a scouring model. The hydrodynamic (scouring) model consists of a progression of mathematical relationships relating the drilling fluid hydrodynamic forces to a well cutting resting on a well bottom. The forces considered that act upon a well cutting are the hydrodynamic drag lift forces, and the submerged weight of the cutting. These forces can be related to the angle of repose, which is dependent on the cutting nature (sandstone, shale, etc.). These forces can be described as functions of the cutting size and density, fluid density, and fluid velocity. The relationship between the hydrodynamic forces and the angle of repose thus gives an equation predicting the critical incipient velocity; this velocity is the velocity required by the fluid to initiate movement of the well cutting and thus, inherently predicts the cleaning ability of the well bottom by the drilling fluid. From the hydrodynamic model describing the critical fluid velocity, it can be concluded that various factors can lower this critical velocity: decreasing the cutting density to drilling fluid ratio; decreasing the cutting size; and increasing the angle of inclination of the well at a constant angle of repose. 9 refs., 3 figs., 3 tabs.

6841 (CIM/S–CE-02846, pp. 7) **Advances in cement slurry application.** Lancaster, G. (Canadian Fracmaster, Ltd. (Canada)); Gray, S. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

Difficulties attributed to poor cement bonding, i.e. annular gas migration and poor zonal isolation, have been encountered in oil wells of southern Saskatchewan. Over the past year, Canadian Fracmaster has been successful in using a thixotropic cement blend with both expanding properties and ultra-low fluid loss. This cement slurry also has a transition time from liquid to set cement that is very short. Variations in rheology, flow regime, and fluid loss have been attempted to obtain a good quality cement job. The most important criteria for obtaining a good cement job are proper casing centralization, efficient mud removal, and constant slurry properties. Increasing the pumping rate is the single most effective way of increasing mud displacement efficiency. Two oil wells serve to illustrate the success of this new cementing technique. 8 refs., 3 figs., 3 tabs.

6842 (CIM/S–CE-02846, pp. 10) **The promise and problems of enhanced oil recovery methods.** Farouq Ali, S.M. (Univ. of Alberta, Edmonton, AB (Canada)); Thomas, S. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

Enhanced oil recovery (EOR) methods are discussed in light of field experience including: polymer flooding, miscible displacement, micellar flooding, steam injection, in situ combustion, and other recovery methods such as surfactant flooding and alkaline flooding.

The reasons for their lack of success are examined. Rather than to give screening criteria, the processes are discussed in terms of mobility ratio and capillary number. It is shown that some of the processes, such as the chemical floods, have intrinsic limitations which explain their lack of success in the field as opposed to the laboratory. Looking at the EOR methods which have been commercially successful, steam injection has the greatest chance of success, miscible displacement may be successful under rather special conditions, and carbon dioxide (miscible) flooding is still somewhat of a question mark, although it has potential. In situ combustion has lost much of its past appeal, but wet combustion may work where steam is not applicable. The same is true for the immiscible carbon dioxide process. Micellar flooding has been proven in the field, but remains a complex, high cost process. Of the remaining chemical methods, polymer flooding may yield modest incremental oil. Alkaline and surfactant floods have great research potential, but are high risk field processes. All EOR methods are low margin operations under the best circumstances.

6843 (CIM/S–CE-02846, pp. 12) **Insights on reservoir heterogeneities and performance of waterflood at the Bonr Creek unit obtained from interwell tracer interpretations.** Singhal, A.K. (Premier Reservoir Engineering Services Ltd.); Nieuwenburg, G.; Dagdick, L.; Roach, M. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

An extensive interwell tracer program was conducted at the Bone Creek Unit oil deposit between 1984 and 1986. The objectives were to obtain insights into the flow distribution and to infer clues regarding potential improvements to the waterflood. Detailed interpretations of tracer returns helped in refining reservoir description in terms of laterai as weii as vertical heterogeneities. These additional details were independently verified by a history match of the unit's performance and were, by and large, consistent with the cross-section fence diagrams of the pay zone prepared from logging and core data. Based upon the composite knowledge thus obtained, a better understanding of sweep patterns around different injectors resulted. The combination of tracer results, production and pressure behaviour reinforced the earlier speculation that only the more permeable intervals - namely, the quartz sand members were being drained, and that the calcareous sandstone members were being bypassed. This offers a challenging problem which needs to be investigated in further detail. The tracer program led to certain changes in injection-production patterns. Four infill wells were drilled. Several additional infill locations were identified. Many parts of the unit, such as the northwestern portion, experienced poor sweep and poor oil recovery. These were caused, in part, by reservoir heterogeneities. With the improved knowledge of these heterogeneities, appropriate enhanced oil recovery schemes for the unit were explored. Similarly, a better understanding of the performance of the waterflood provided clues to its possible improvement. 12 refs., 18 figs., 4 tabs.

6844 (CIM/S–CE-02846, pp. 16) **A labratory miscible displacement study for the recovery of Saskatchewan's crude oil.** Huang, S.S.; Wit, P. de; Jha, K.N. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

Most of Saskatchewan's light and medium oil reservoirs have reached economic limits of production under waterflooding, leaving 70 to 80% of the initial oil-in-place in the reservoirs. The miscible displacement process using carbon dioxide, hydrocarbon, and other gases as solvents appears to be one of the most promising method for these reservoirs. A laboratory study was conducted to evaluate the applicability of various solvents for the recovery of oil from a southeast Saskatchewan reservoir. The physical, chemical, and phase behavior properties of wellhead and reservoir fluids were determined. Slim tube displacement tests were conducted between the reconstituted Pinto reservoir fluid and carbon dioxide, ethane, and wellhead gas from the Steelman gas plant as solvents at various pressures and at the reservoir temperature of 56^{0}C. The density and viscosity of the Pinto wellhead oil and the reconstituted Pinto reservoir fluid increasing with rising pressure, and these values decreased with temperature. The minimum miscibility pressures (MMP) for the Pinto reservoir fluid with carbon dioxide, with ethane, and with the wellhead gas from the Steelman gas plant were determined. The obtained data indicated that the MMP for ethane is lower than that for carbon dioxide, which is lower than that for Steelman gas. The MMP for ethane and carbon dioxide are well below the reservoir fracture pressure. The slim tube studies demonstrated that the miscible displacement process using carbon dioxide or ethane as a solvent is a promising technique. Ethane, when used as a solvent for the Pinto reservoir, was demonstrated to be more effective than CO_2 in achieving miscibility with oil. 14 refs., 9 figs., 11 tabs.

6845 (CIM/S–CE-02846, pp. 32) **Vertical confined water drive to horizontal well. Part I: Water and oil of equal densities.** Supronowicz, R. (Univ. of Calgary, Calgary, AB (Canada)); Butler, R.M. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

The use of horizontal wells for oil reservoirs with underlying water is attractive because water production may be reduced. In this paper, the displacement of oil by a rising water crest is considered. This is the main mechanism by which oil is produced where operation above Muskat's critical coning rate is required. The arrangement which has been studied involves a series of very long, equally-spaced, parallel, horizontal wells locateo just below a horizontal reservoir boundary. It is first assumed that the oil and water have the same properties and methods are given for calculating the progress of the interface. Decreasing the well spacing improves the fractional recovery but reduces the production quantity per well. The method extends to infinite well spacing, i.e. to isolated wells. The effect of oil and water densities and viscosities on the stability of the rising crestal interface are also considered. There is a critical production rate beyond which fingering will occur. This critical rate for fingering is different from that for cresting or coning and it presents a serious limitation to the effectiveness of horizontal wells for the production of heavy oil from reservoirs with underlying aquifers. With heavy oils, production at economic rates involves not only displacement by a rising water crest, but also, because of viscous instability, the fingering of water upwards through the oil above the crest.

6846 (DOE/BC–89/9/SP) **Major program elements for an advanced geoscience oil and gas recovery research initiative: Program study summary report: Recommendations and research activity priorities: [Final report].** Texas Univ., Austin, TX (USA). Geoscience Inst. for Oil and Gas Recovery Research. 1989. 50p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FG22-88BC14265. Order Number DE90004037. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

The Geoscience Institute, a consortium of leading national universities and state research agencies with established advanced oil and gas recovery research capabilities, initiated the program study in May 1988. The Geoscience Institute's program study report is summarized in three volumes. This volume is the Program Study Summary Report, which contains recommendations for program option and descriptions of the highest priority research activities. The Technical Subcommittees Program Reports (Geoscience Institute, 1988b) provide detailed descriptions of individual research activities related to the study's six major program elements. Summary reports from a series of Regional Technical Forums, hosted by the Institute (1988c) focus on technology needs related to specific hydrocarbon provinces. These reports document and comprise the broadest based oil and gas recovery program study recommendations developed in the public sector. 27 refs., 17 figs., 8 tabs.

6847 (EUR–12162) **Displacement of oil by water in porous media and determination of flowing laws: Final technical report.** Bieber, M.T. (GERTH, 92 - Rueil-Malmaison (France));

Bourbiaux, B.; Legait, B.;. Commission of the European Communities, Luxembourg (Luxembourg). Directorate General Telecommunications, Information Industries and Innovation; GERTH, 92 - Rueil-Malmaison (France). c 1989. 113p. Sponsored by Commission of the European Communities. EN 3C-0017F (CD). Available from NTIS (US Sales Only), PC A06/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg; Price: ECU 10.

In order to predict the behavior of a reservoir subjected to water injection, the reservoir engineer needs hydrodynamic data characterizing the reservoir. Most of these hydrodynamic data are obtained from laboratory work, by performing oil and water flow experiments in reservoir samples. The measured data (porosity, permeability, relative permeabilities, capillary pressures) are then entered in a numerical model which solves the multiphase flow equations for porous media. The purpose of this study was twofold: (1) Improve the knowledge of multiphase flow laws in a porous medium: Capillary pressure and relative permeability equations were examined. (2) Improve experimental methods and procedures. 13 refs., 62 figs., 5 tabs.

6848 (INIS-mf–12026) **Application of nuclear process heat from pebble-bed HTR reactors for enhanced recovery of petroleum. Final report.** Jaeger, H.; Fricke, U.; Inhester, K.H.; Kammel, R.; Kugeler, K.; Muehlensiep, J.; Philippen, P.W.; Schmidtlein, P.; Wagner, U. Duisburg Univ. (Gesamthochschule) (Germany, F.R.). Fachgebiet Energietechnik; Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). Oct 1986. 196p. (In German). Contract BMFT 03 UGD 301. Order Number DE90732341. Available from NTIS (US Sales Only), PC A09/MF A01.

With the help of the steam injection process, about a twofold increase of the economically accessible oil reserves can be attained worldwide. Projects for the production of oil with the help of enhanced recovery methods will become increasingly important within the next few years. Fossile fuel resources are excellently protected with high-temperature pebble-bed reactors, since by retaining conventional methods of energy supply more than half the oil produced or of the light products would have to be burnt again for such production projects. Under the defined technical and economic outline conditions, a successful application of HTR technology can be expected in tertiary oil production. (orig.). With 5 refs., 31 tabs., 88 figs.

6849 (NEI-NO–100, pp. 12) **NTNF's research and development programs in offshore technology.** Milch, S. (Norwegian Council for Scientific and Industrial Research, Oslo (Norway)); Loeken, T. Norges Teknisk-Naturvitenskapelige Forskningsraad, Oslo (Norway). 1989. (CONF-8906258–: 1989 NTNF oil and gas conference, Oslo (Norway), 13-14 Jun 1989). In *Norwegian oil and gas in a low-price market.* Order Number DE90728220. Available from NTIS (US Sales Only), PC A12/MF A01.

In this paper the Norwegian offshore research programs, financed by the Norwegian Council for Scientific and Industrial Research (NTNF) are presented. The four programs of today are: Gas ultization SPUNG; Drilling technology; Multiphase technology PROFF; Floating production systems FPS2000. The SPUNG program will be presented in another paper. The three other programs all commenced early 1989. The Drilling technology program has been split in 3 subprogram areas. Directional and horizontal drilling, optimization and efficiency improvements, and new drilling methods. Multiphase technology is an area where research institutes and industrial companies in Norway are in the front on a world-wide basis. Four areas are defined as special important to the program: Multiphase flow technology to establish physiomathematical and numerical models for engineering and design of multiphase systems; Prediction of fluid-dependent effects like hydrate and wax formation, emulsion, foam formation and the development of inhibiting methods; Selection of materials and inhibitor systems to combat corrosion and erosion; Development of instruments, monitoring and control systems. Although the first and second generation of floating production systems are in operation today, certain technology bottlenecks hamper the more extensive use of floating production installations. A perequisite in the program specification has been to refrain from conceptual and pre-engineering studies and to concentrate on research and development work needed to widen scope for a wider application of floating production systems. The 3-year program, starting in 1989, should lead to industrial products and services within a fairly short time.

6850 (NEI-NO–100, pp. 257) **Fractals and porous media.** Feder, J. (Oslo University (Norway)). Norges Teknisk-Naturvitenskapelige Forskningsraad, Oslo (Norway). 1989. (CONF-8906258–: 1989 NTNF oil and gas conference, Oslo (Norway), 13-14 Jun 1989). In *Norwegian oil and gas in a low-price market.* Order Number DE90728220. Available from NTIS (US Sales Only), PC A12/MF A01.

Fractals extend the traditional Euclidean geometry in a way that allows us to characterize the structure and dynamics of many of the processes observed in nature. Fractal geometry is required for phenomena that arise from the interplay of many length and time scales. Fractal geometry is easily recognized in situations where the phenomena are self-similar, i.e., they look the same on all length scales. The displacement of one fluid by another in porous media may lead to fractal displacement fronts. In homogeneous porous models experiments show that at high displacement rates one finds a fractal viscous fingering structure both for miscible and immiscible flow when the viscosity of the driving fluid is below that of the fluid being produced. At very low displacement processes on the other hand one observes fractal invasion percolation structures, which leave trapped regions of oil of all sizes behind the front. A new type of fractal front has been observed in the dispersion of tracers in a fluid flowing in two-dimensional porous models. The concentration contours are self-affine fractal curves with a fractal dimension D=1.42. The main conclusion is that fluid-fluid displacement processes in porous media lead to fractal displacement fronts and fractal regions of trapped oil. It is important to realize that this fact implies that averaging and extrapolation from the laboratory to the field scale has to be done with the greatest care. The residual oil saturation for example depends on the size of the region under study. 38 refs., 15 figs., (Author).

6851 (NIPER–431) **Gas miscible displacement: Foams for mobility control and improvement in gas sweep efficiency.** Llave, F.M.; Chung, F.T.H.; Louvier, R.W.; Hudgins, D.A. National Inst. for Petroleum and Energy Research, Bartlesville, OK (USA). Dec 1989. 55p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FC22-83FE60149. Order Number DE90000205. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This report presents the results of experimental studies relating to mobility control and sweep efficiency in gas flooding that were focused on several topics: (1) the study of foam flow behavior in smooth capillary tubes and packed glass tubes; (2) the effect of injection rate on foam performance; and (3) the study of the effect of foam on gas-water relative permeabilities. The study of foam flow behavior in smooth capillary tubes and packed glass tubes was designed to observe and quantify the behavior of foam under various experimental conditions. Experimental variables included foam quality, shear rate, surfactant concentration, and temperature. Apparent viscosity, resistance factor, and reduction in the mobility of foam in smooth capillary tubes and packed glass tubes were measured. Bubble size distribution of pregenerated foam was measured to determine the contribution of foam texture to its flow behavior. A comparison of the experimental results was made using available mathematical models developed for predicting foam apparent viscosities in smooth capillary tubes and packed glass tubes. Several coreflooding experiments were conducted. Using single cores, gas-water relative permeabilities were measured to determine the effects of foam. 42 refs., 44 figs., 6 tabs.

6852 (NIPER–432) **Crosslinked, flexible, low-molecular-weight polyacrylamide gels for mobility control: Topical report.** Gao, H.W. National Inst. for Petroleum and Energy Research, Bartlesville, OK (USA). Dec 1989. 15p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FC22-83FE60149. Order Number DE90000202. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This project is a continuation of a research program initiated in FY88 to develop shear-resistant flexible gels based on crosslinking

a low-molecular-weight polyacrylamide for mobility control. Polyacrylamide was crosslinked with aluminum citrate and chromium citrate. This report is divided into three parts: (1) gelation tests, (2) shear degradation and rehealability tests, and (3) porous media studies. Gelation tests showed that crosslinked low-molecular-weight polyacrylamide gels for mobility control can be formulated at pH = 7.0 using a low-molecular-weight polyacrylamide polymer, HPAM1 (molecular weight = 400,000 daltons) at concentrations from 10,000 to 20,000 ppM and a crosslinker, aluminum citrate, at aluminum concentrations from 150 to 2,400 ppM. Porous media studies showed that weak gels were injectable through porous media. Shear degradation tests for a weak gel in a porous medium (permeability = 197 darcies) consisting of a pack of five 100-mesh stainless steel screens showed that crosslinked bonds were broken under a high shear condition and rehealed under a low shear condition. 14 refs., 8 figs., 3 tabs.

6853 (NIPER–442) **Effects of chemical additives on microbial enhanced oil recovery processes.** Bryant, R.S.; Chase, K.L.; Bertus, K.M.; Stepp, A.K. National Inst. for Petroleum and Energy Research, Bartlesville, OK (USA). Dec 1989. 30p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FC22-83FE60149. Order Number DE90000204. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

An extensive laboratory study has been conducted to determine (1) the role of the microbial cells and products in oil displacement, (2) the relative rates of transport of microbial cells and chemical products from the metabolism of nutrient in porous media, and (3) the effects of chemical additives on the oil recovery efficiency of microbial formulations. This report describes experiments relating to the effects of additives on oil recovery efficiency of microbial formulations. The effects of additives on the oil recovery efficiency of microbial formulations were determined by conducting oil displacement experiments in 1-foot-long Berea sandstone cores. Sodium tripolyphosphate (STPP), a low-molecular-weight polyacrylamide polymer, a lignosulfonate surfactant, and sodium bicarbonate were added to a microbial formulation at a concentration of 1%. The effects of using these additives in a preflush prior to injection of the microbial formulation were also evaluated. Oil-displacement experiments with and without a sodium bicarbonate preflush were conducted in 4-foot-long Berea sandstone cores, and samples of in situ fluids were collected at various times at four intermediate points along the core. The concentrations of metabolic products and microbes in the fluid samples were determined. 9 refs., 22 figs., 8 tabs.

6854 (NIPER–447) **Use of sacrificial agents to reduce carboxymethylated ethoxylated surfactant loss during chemical flooding.** Gall, B. National Inst. for Petroleum and Energy Research, Bartlesville, OK (USA). Dec 1989. 27p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FC22-83FE60149. Order Number DE90000203. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Surfactant losses of carboxymethylated ethoxylated surfactants (CME) were measured in static and coreflood experiments. The effect of several types of sacrificial agents on CME adsorption were also measured. In static tests, lignosulfonate and sodium carbonate/bicarbonate were effective sacrificial agents at low salinity or low temperature conditions. Under these conditions, surfactant loss was mainly a result of adsorption on the rock surface. However, these agents were less effective at higher salinities and temperatures where surfactant phase separation becomes an important mechanism for surfactant loss. Similar results were observed in oil recovery experiments using Berea sandstone cores and dodecane. However, under conditions which favored low surfactant retention, the surfactant was ineffective in mobilizing oil. Under conditions which produced at least some oil from the core, surfactant losses were excessively high. The most successful oil recovery conditions were observed using a CME in solution with pH adjusted to the pK_a of the carboxylate group (pH = 4.6 for a CME surfactant with an average of 6.5 ethoxylate groups per molecule). This may help balance the surfactant affinity for both oil and brine. 16 refs., 12 figs., 11 tabs.

6855 (PCCIM–CE-02786-2.vols, pp. 21) **Laboratory study of the use of foam in cyclic steam injection.** Green, M.K. (Alberta Research Council, AB (Canada)); Isaacs, E.E.; Chhom, K.N. Petroleum Society of CIM (Canada). 1989. (CONF-8905249–: 40. annual technical meeting of the Petroleum Society of the Canadian Institute of Mining and Metallurgy (CIM), Banff (Canada), 28-31 May 1989; CE–02786). In *Building on 40 years of achievement: Volumes 1 and 2.* Available from Petroleum Society of the CIM, c/o AMOCO Canada, Box 200, Calgary, AB, CAN T2P 0H8. Prices: $80.00 CAN.

The paper deals with the process of foam injection for improving conformance and increasing oil recovery, which has been successfully employed in a number of steamflooding operations. This work was carried out to develop a methodology for cyclic steam laboratory studies and provide some understanding of the performance of surfactants foams in a cyclic process in Alberta's heavy oil resources. Runs were carried out by cycling the production pressure between 700 and 1750 pascals at one end of the core while injecting steam at a constant rate into the other end. The formation of the foam within the flow path during the drawdown and low pressure periods wes inferred from the higher pressure changes observed when surfactants was used. Foam formation occurred most readily during the low pressure phase. The presence of a relatively high concentration of surfactants was required to cause foaming during the drawdown. Non-condensable gas coinjected with surfactants had little or no effect on pressure drop behaviour. The influence of drawdown rate was also investigated. The results showed that foam formation occurred much more readily at low oil saturations and both N_2 coinjection and flow path permeability were found to have little effect on the performance of the foaming surfactants. 15 refs., 18 figs., 5 tabs.

6856 (RISO-M–2810) **Simulation of matrix fluid displacement in fractured reservoirs.** Energiministeriets Energiforskningsprogram. Olie- og gasreservoirmodeller. Rapport, 20. Ladekarl Thomsen, K. Risoe National Lab., Roskilde (Denmark). Jun 1989. 128p. Contract EM 1313/86-10. Order Number DE90728135. Available from NTIS (US Sales Only), PC A07/MF A01.

EFP-86. In cooperation with Danmarks Tekniske Hoejskole, Laboratoriet for Energiteknik and Danmarks Geologiske Undersoegelse.

Computer simulations of bead-pack experiments in a matrix-fracture configuration are compared with measurements to evaluate the applicability of a traditional reservoir simulator with appropriate treatment of boundary conditions. Furthermore, the flow equations are transformed to dimensionless form, and a series of 1-D simulations has been performed to investigate parametrically the types of matrix-fracture behaviour that can occur under various conditons. On the basis of these investigations, imbibition experiments reported in the literature are reviewed critically. The serious doubts raised by some authors about the validity of scaling laws derived from the flow equations using Darcy's law seem to be due to experimental problems. It is concluded that detailed simulation using the traditional model is appropriate. (author) 9 tabs., 74 ills., 34 refs.

0204 Processing

Refer also to citation(s) 6626, 6629, 6678, 6679, 6680, 6681, 6686, 6942, 6943, 7053, 8090

6857 (IT–CE-02787, pp. 17) **The maintenance, inspection and monitoring of production tanks.** Stricker, D.J. (Petro-Canada Inc., Calgary, AB (Canada)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

The paper deals with the maintenance, inspection and monitoring of production tanks from the viewpoint of corrosion control. More specifically it covers the programs which are required to maintain a tank's material integrity. Examples have been provided to demonstrate what can happen when all the conditions for a corrosion cell are met. External cathodic protection, internal cathodic protection; insulation considerations; and annual turnaround inspections of the production tanks are covered in detail. Pictures of the production

tanks to show these characteristics under different conditions are included. 16 figs.

6858 X-ray absorption study of vanadium in FCC catalysts. Woolery, G.L. (Mobil Research and Development Corporation, Paulsboro, NJ (USA)); Chin, A.A.; Kirker, G.W.; Huss, A. Jr. *American Chemical Society, Division of Petroleum Chemistry, Preprints (USA),* 32(3): 663-668 (Aug 1987). (CONF-8708311–: Symposium on advances in FCC, New Orleans, LA (USA), 30 Aug - 4 sep 1987).

X-Ray absorption spectroscopy (XAS) is a very powerful tool that can provide useful information concerning the interaction of V with FCC catalysts. This technique refers to the ejection of an inner core electron (photoelectron) from an atom as a result of X-ray absorption. Since each element has its own characteristic binding energy, it is possible to examine a specific element in the presence of many others by tuning the X-ray energy to the proper absorption edge. The position of the K absorption edge gives information regarding the effective nuclear charge exerted on the core electrons. The backscattering of the emitted photoelectron by neighboring atoms (EXAFS) provides information about the immediate environment surrounding the absorber atom. Thus, XAS is ideal for amorphous or poorly crystalline systems, such as may be found in zeolite destruction by vanadium, since it does not rely on long range ordering. Furthermore, with the availability of high intensity X-ray sources (synchrotron radiation), XAS is extremely sensitive, with the capability of providing chemical information on metals at the hundred ppm concentration level. In this paper, we demonstrate the type of information that can be obtained from the application of XAS to metal containing systems. Examples are discussed from our V absorption edge studies undertaken to improve understanding of: the mechanism of V deactivation, the effects of processing conditions, and the chemistry of known V passivators. Supplemental data were provided by bench unit evaluations of the V-containing FCC catalysts.

6859 Catalytic cracking of a Wilmington vacuum gas oil and selected hydrotreated products. Wells, J.W. (IIT Research Institute, Bartlesville, OK (USA)). *American Chemical Society, Division of Petroleum Chemistry, Preprints (USA),* 32(3): 699-702 (Aug 1987). (CONF-8708311–: Symposium on advances in FCC, New Orleans, LA (USA), 30 Aug - 4 sep 1987).

The presence of heteroatom, organometallic, and polynuclear aromatic (PNA) compounds in the catalytic cracker feed can cause pollution problems, catalyst deactivation problems (permanent or temporary), and product stability problems. One way of controlling these factors is to hydrotreat the feedstock prior to catalytic cracking. In this paper, the effects of hydrotreating on feedstock response to cracking, heteroatom (S, N) distribution, and light gas composition have been summarized. For further details the reader is referred to Wells and Zagula.

6860 Extended x-ray absorption fine structure spectroscopic (EXAFS) studies of model reforming catalysts. Meitzner, G. (Exxon Research and Engineering Company, Annandale, NJ (USA)); Via, G.H.; Sinfelt, J.H.; Lytle, F.W. *American Chemical Society, Division of Petroleum Chemistry, Preprints (USA),* 32(3): 733-736 (Aug 1987). (CONF-8708312–: Symposium on advances in naphtha reforming, New Orleans, LA (USA), 30 Aug - 4 sep 1987).

Catalysts containing rhenium and platinum, developed by workers at Chevron, are among those used in reforming reactions for synthesis of aromatic hydrocarbons used in gasoline. The state of reduction of rhenium and the extent of the interaction between rhenium and platinum have been the subject of discussion. We have made a study with extended X-ray absorption fine-structure spectroscopy (EXAFS) of an alumina-supported rhenium-platinum bimetallic catalyst to address these issues. We have also examined a sulfided catalyst. The analyses of EXA FS from the rhenium-platinum catalyst was complicated by the similarity of the electron back-scattering properties and poor separation of the absorption edges of the two metals (because their atomic numbers are close together). Therefore we included in this work a sample that contained rhenium and palladium supported on alumina. Rhenium and palladium are easily discriminated with EXAFS, and we assumed that some of the same structural features may be present.

0205 Products and By-Products

Refer also to citation(s) 6946

0206 Health and Safety

Refer also to citation(s) 6888

6861 (CPA–CE-02811) **Report of the Upstream Petroleum Industry Task Force on Safety.** Canadian Petroleum Association, Calgary, AB (Canada). 1988. 102p. (CE–02811). Available from Canadian Petroleum Association, 3800-150 6th. Ave. S.W., Calgary, AB, CAN T2P 3Y7. Prices: $25.00 CAN.

This report summarizes the work and recommendations of the Upstream Petroleum Industry Task Force on Safety and identifies its main objectives and functions. It summarizes 42 recommendations as well as the factors that led to the formation of each recommendation. The first 26 recommendations apply to most industry sectors and to government, while the remaining 16 apply to specific sectors of the industry. Key areas and guiding principles of the study are given. Recommendations are provided in the following areas: elements of a minimum basic safety program; importance of including safety factors as part of bidding procedures and contract terms; accident reporting protocols; the importance of a goverment initiative in smoothing out the boom or bust cycle in oil drilling activities; improvements in occupational health and safety regulation and inspection procedures; training of work site supervisors; industry training programs; and establishment of safety awards in the industry. Also recommended is the establishment of an industry safety implementation committee to ensure that the recommendation be adopted and to monitor safety improvements. Specific recommendations are made to the drilling operations; exploration; field construction and transportation sectors. Information is provided in appendicies on the Workman's Compensation Board industry classifications; Occupational Health and Safety Association members; occupational health and safety guidelines; industry association descriptions; a new employee safety orientation program; elements of the recommended basic safety program; an on the job training program; a rig inspection checklist; and a list of task force members. A summary list of recommedations is also included. 27 figs., 6 tabs.

0207 Economic, Industrial, and Business Aspects

Refer also to citation(s) 7669

6862 (AMPC–89-05821) **Alberta Petroleum Marketing Commission annual report, 1988.** Alberta Petroleum Marketing Commission, Calgary, AB (Canada). [1990]. 36p. (MICROLOG–89-05821). Available from PC Alberta Petroleum Marketing Commission, 1900-250 6th Ave. S.W., Calgary, AB, CAN T2P 3H7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

The Alberta Petroleum Marketing Commission has the responsibility of selling the Crown's royalty share of Alberta's crude and synthetic oil production; similar services are provided for natural gas including price regulation duties and information collection. The Commission also markets crude oil on behalf of over 175 producers to North American and offshore consumers. The Commission's position as the largest crude oil marketer in Canada enables it to provide analyses of industry pricing and marketing trends to the Alberta government. In 1988, total deliveries of crude oil to points outside Alberta rose 25% from 1987 to 51 million bbl. Volatile world oil prices and domestic transportation bottlenecks created a climate of market uncertainty for Alberta producers and marketers in that year. Locally, capacity shortages along the Interprovincial Pipe Line system presented major problems for producers attempting to access eastern and midwestern markets. The year was generally profitable for refiners, and the Free Trade Agreement with the USA is felt to enhance the potential of Alberta crude as a secure, long-term supply source. Total revenue from royalty sales of conventional crude was $962 million, down 26% form 1987. The volume of synthetic crude sold by the Commission was 9.2 million bbl, up 7.1% from 1987. This review of the year's activities also includes the Commission's financial statements. 8 figs., 1 tab.

6863 (CIM/S–CE-02846, pp. 11) **Reducing production operating costs: Its field consolidation the answer?.** Fitzpatrick, D.M.; Ruzucki, E.V. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

A reduction in production operating costs, as a direct result of field consolidation, lowers a well's economic producting cost limit and enhances the current value of the producing property. Field consolidation is examined in this paper as a method of reducing operating costs and increasing production in an effort to maximize revenue and field life. Consolidation schemes ranging from single well programs to the tie-in of multiple wells are addressed in terms of the incentives, relative costs, and resulting economic benefits of consolidating or continuing to produce as single well batteries. Economic guidelines are provided to enable other operators to assess the probable merit of a consolidation scheme. As the major operator in the Kisbey field in southeastern Saskatchewan, Canadian Hunter Exploration Ltd. undertook an intensive consolidation program in late 1988/early 1989, tying in 19 producing oil wells and constructing full-battery facilities. The new operating scheme has significantly increased the value of this property by immediately reducing operating costs and by minimizing production down time. Pre- and post-consolidation operating costs are discussed in detail to illustrate the magnitude of the cost savings. Ultimate hydrocarbon recovery in Kisbey will be maximized as a result of the incremental reserves attributed to the lower economic producing cost limit. 2 refs., 12 figs.

6864 (CIM/S–CE-02846, pp. 14) **Outlook for the 1990's.** Crandall, G.R. (Hycarb Engineering Ltd. (Canada)). Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

This paper discusses the outlook of the markets for oil and gas in the 1990s. The part of Organization of Petroleum Exporting Countries in the oil production for the west will increase; the price of light crude in the US, expressed in constant dollars, will increase slowly; the US will become more reliant on imported crude (from 47% in 1989 to 56% in 2000); Canadian light crude production will decline with respect to total production of hydrocarbons and this country will likely become a net oil importer by the year 2000; the US Mid-West market will remain the main outlet for Canadian heavy crude; Canadian demand and exports of natural gas will continue to increase and by the year 2000, this country will have to exploit frontier supplies. The challenges presently facing Western Canadian producers are to maintain the production of oil and gas to meet market demands with a risk of low prices, to prepare for growth in the same conditions to improve efficiency in all the aspects of oil and gas business, to respond to growing environmental concerns regarding crude oil and even natural gas, and to develop and adapt new technology into oil and gas developments.

6865 (CPA–CE-02812, pp. 69-104) **Economic and fiscal realities.** Russell, G. (Gulf Canada Resources (Canada)); Dingwall, R.; Odenbach-Sutton, P.; Inkster, D. Canadian Petroleum Association, Calgary, AB (Canada). 1988. (CONF-8805349–: 15. CPA (Canadian Petroleum Association) Frontier Division workshop, Fairmont (Canada), 8-11 May 1988; CE–02812). In *Managing transition on the Canadian petroleum frontiers.* Available from PC Infopall, Pallister Resource Management, Bay 105, 4116 - 64th. Ave., S.E., Calgary, AB, CAN T2C 2B3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $24.00 CAN; MF $10 CAN.

A series of presentations and a panel discussion representing a variety of points of view on the economic and fiscal realities of frontier development is provided. Included in the panel were representatives of a large company that is promoting development, a small Canadian company promoting joint venture partnerships, and the federal and provincial governments. The first presentation concerned investment considerations for Gulf Canada Resource's Amauligak development, outlining factors considered in planning, and the risk and return for Gulf and Canadians. The second presentation assessed a joint venture partner's position, based on world oil price, hydrocarbon potential, markets and transportation systems, timing of first production, and economic reality. The third presentation gave a federal government view of the examination of the economic and policy issues concerning frontier megaproject development, first outlining the federal fiscal regime applicable to the frontier area and the change in investor returns, then making a comparison to Australia, Norway, the United Kingdom and the United States. A list of government criteria used in assessing alternative assistance mechanisms concluded the presentation. The last presentation covered the provincial situation, focusing on Newfoundland and outlining the potential contribution of the petroleum resources of the Newfoundland continental margin to national security and the economic well-being of Canada in general, and that of Newfoundland in particular. 10 figs., 5 tabs.

6866 (CPA–CE-02812, pp. 3-36) **International and national perspectives.** Maciej, H. (Canadian Petroleum Association, Calgary, AB (Canada)); Woolveridge, M.; Herrera, R.; Pallister, E. Canadian Petroleum Association, Calgary, AB (Canada). 1988. (CONF-8805349–: 15. CPA (Canadian Petroleum Association) Frontier Division workshop, Fairmont (Canada), 8-11 May 1988; CE–02812). In *Managing transition on the Canadian petroleum frontiers.* Available from PC Infopall, Pallister Resource Management, Bay 105, 4116 - 64th. Ave., S.E., Calgary, AB, CAN T2C 2B3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

This presentation began with a discussion of petroleum as an international commodity, and the role of OPEC in determining price and supply, concluding that lower prices and uncertainty of supply would be common for the near future and while industry has adjusted to lower prices, governments have yet to do so. A more specific focus was then taken, with the history of exploration and development of the BP Magnus field in the North Sea and the Alaskan fields, particularly Prudhoe Bay, being considered as examples of how to proceed and how not to proceed. The session concluded with consideration of the exploration in Canada's northern frontier areas and the need for development of these areas.

6867 (DOE/EIA–0520(89/11)) **International petroleum statistics report.** USDOE Energy Information Administration, Washington, DC (USA). Office of Energy Markets and End Use. 28 Nov 1989. 38p. Sponsored by U.S. DOE Energy Information Administration. Order Number DE90003177. Available from NTIS, PC A03/MF A01 - GPO - OSTI; GPO Dep.

This report presents data on international oil production, consumption, imports, exports, and stocks. The report has three sections. Section 1 contains time series on world oil production, and on oil consumption and stocks in the Organization for Economic Cooperation and Development (OECD). This section contains annual data beginning in 1973, and monthly data for the most recent two years. Section 2 presents an oil supply/consumption balance for the market economies (i.e., non-communist countries). This balance is presented in quarterly intervals for the most recent two years. Section 3 presents data on oil imports by OECD countries. This section contains annual data beginning in 1982, and quarterly data for the most recent two years. 21 tabs.

6868 (MEM/P–89-05719) **Manitoba oil activity review, 1988.** Manitoba Dept. of Energy and Mines, Winnipeg, MB (Canada). Petroleum Div. Jun 1989. 52p. (MICROLOG–89-05719). Available from PC Manitoba Energy and Mines., Information Centre, 555-330 Graham Ave., Winnipeg, MB, CAN R3C 4E3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

In an annual survey of Manitoba's petroleum industry, data are presented on oil and natural gas leases and sales, geophysical activity, exploration and drilling activity, production, exports to other provinces and USA, oil prices and sales value, royalties and taxes, direct revenues from oil exploration and development, reserves,

industry expenditures, and oil fields. Throughout the report, explanations are given of the items covered. Descriptions are made of new developments, the oil market, oil policies, incentive programs, and industrial activities. A forecast for the following year is outlined; petroleum activity in Manitoba in 1989 is not expected to exceed 1988 activity levels. 17 figs., 20 tabs.

6869 (NEI-NO–72) **Bergen conference on oil and economics: Bergen, May 3-4, 1988.** Norsk Petroleumsforening, Oslo (Norway). 1988. 134p. (CONF-8805343–: Bergen conference on oil and economics, Bergen (Norway), 3-4 May 1988). Order Number DE90728218. Available from NTIS (US Sales Only), PC A07/MF A01.

The conference proceedings contain 7 papers. The topics covered are: Possible oil supply distribution and IEA's contingency plan; The oil market and economic progress in third world countries; The impact of oil on the foreign policies of the superpowers and its ramifications on the oil market; The role of the international oil market in Soviet oil policies; International trade -Status and possible developments. Do oil producers hold any particular responsibility; Economic and political issues in the Middle East oil exporting countries; Coping with political risks - business strategies in the case of Mobil. Separate abstract was prepared for one of the papers.

0208 Waste Management

Refer also to citation(s) 6856, 6858, 6884, 6947, 7507, 7727, 8184, 8382

6870 (BES–89-03895) **Review and evaluation of equipment for utilizing waste oil as a fuel for heating in the N.W.T.** Boreal Ecology Services Ltd., Yellowknife, NT (Canada). Mar 1988. 127p. (MICROLOG–89-03895). Available from PC Northwest Territories. Dept. of Renewable Resources, P.O. Box 1320, Yellowknife, NT, CAN X1A 2L9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

By carefully controlled burning of the waste oil at its source within the community, and by utilizing the resultant heat, northern communities will benefit in at least 3 ways: the high cost of storing or transporting waste oil is eliminated; the contamination of the environment is reduced; and the dependence on fuel oil is lessened. For example, it has been estimated that a potential exists to recover 259,000 litres of waste oil each year from the Yellowknife area alone; that represents almost 10,000 GJ of energy, enough to heat 20 buildings of 2500 ft^2 during an entire Yellowknife winter. Atomizing oil burners and vaporizing oil burners are compared. A comprehensive list of the available equipment is given, together with a brief evaluation of each product; most of the products listed are approved by one or more of the major testing facilities in North America. In comparing waste oil heaters the important factors to be examined are capital cost, operating and maintenance costs, ease of operation, controllability, reliability, emissions and efficiency. The aspect of safety is evoked at the beginning of the report and seems to be in favor of atomizing burners; however, the vaporizing pot burner is less affected by contaminants. In conclusion, the feasibility of waste economics; the factor most critical to the success of an installation will be maintenance. Appendices give the economics of 5 case studies, followed by product literature. 4 refs., 9 figs., 3 tabs.

6871 (INIS-mf–12023, pp. 191-201) **Alkali melting of vanadium-containing residues of petroleum processing with subsequent atomisation for the purpose of vanadium recovery from residues of petroleum processing.** Haehn, R.; Sattelberger, S.; Hess, H. Kernforschungsanlage Juelich GmbH (Germany, F.R.). Projektleitung Material- und Rohstofforschung; Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). 1987. (In German). Contract BMFT 03R048. (CONF-8711333–: Seminar on materials separation and enrichment, Goslar (Germany, F.R.), 23-24 Nov 1987). In *Materials separation and enrichment. Research and development sponsored by the Federal Minister for Research and Technology.* Order Number DE90732327. Available from NTIS (US Sales Only), PC A14/MF A01.

The residues which are of interest to vanadium manufacturers are mainly oil incineration and gasification residues as well as filter ashes from the waste gas purification of power plants in which heavy and residue oils are burnt. In alkaline fusion, the available vanadium compounds are transferred to lightly water-soluble, pentavalent Na vanadates. A recently developed method is described which is non-polluting and economical. (RB).

6872 (IT–CE-02787, pp. 15) **Waste minimization in the petroleum industry.** Fitzpatrick, M. (U.S. Environmental Protection Agency, Washington, DC (USA)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

Waste minimization is a policy mandated by the U.S. Congress to be applied to either volume or toxicity of hazardous wastes. Three major categories of waste generated by the petroleum exploration and production activities have been identified by the Environmental Protection Agency: produced water; drilling muds and cuttings; and associated waste. Each of these categories of wastes presents its own set of waste minimization opportunities. The paper gives the overview of the industry, regulatory background, definition of waste minimization, waste minimization techniques, elements of a successful waste minimization programs, and finally approaches and priorities. It addresses the potential areas for waste minimization as well as the economic, environmental and regulatory incentives to developing a waste minimization program. Elements that can contribute to a successful program, when implemented by the company management, are also discussed. 7 refs.

6873 (IT–CE-02787, pp. 12) **The management and operation of a class 1 landfill.** Penttinen, S. (Dow Chemical Canada Inc., Fort Saskatchewan, SK (Canada)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

This paper deals with the construction of the first double synthetic lined landfill system in Canada built by Dow Chemical at Fort Saskatchewan in 1986. It recognizes that through careful design considerations and operating procedures, a secure system could be maintained to minimize impact to the surrounding environment. The paper describes the design, testing, operating criteria and performance of the system. The system has multiple lining layers. It includes two 100 mill high density polyethylene (HDPE) liners. Between these liners is a drainage net (geonet), geotextile and 15 cm of sand. Outside the secondary HDPE liner is a layer of compact clay and additional layers of geonet and geotextile. Following two years of operation, data was collected and evaluated to confirm that the facility is achieving containment at levels well below suggested de minimis leakage rates. It finally concludes that the design of the double lined system which promotes rapid leachate removal above the primary and secondary system and the synthetic/clay composite secondary liner is instrumental in achieving sound performance. The operating criteria established at Dow along with ongoing performance evaluation, ensures the landfill's long-term integrity. 5 refs., 4 figs., 1 tab.

6874 (IT–CE-02787, pp. 15) **Overview of leachate detection and collection systems at waste containment facilities.** Kewen, T. (Gartner Lee Ltd., Markham, ON (Canada)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

Liner systems are used in all new and retrofitted hazardous waste management facilities. Effective leachate detection and collection in liner systems depends upon careful design and proper attention to

basic drainage principles. It is essential that the drainage layers have high permeability, proper drainage pipe configuration, excess drainage capacity, effective drainage subcompartments, and access for long term maintenance. This paper reviews design criteria for the composite liner system required at hazardous waste landfills in the United States and discusses design criteria that can be used in leachate detection and collection in all liner systems. It is concluded that the material integrity of oilfields production tanks can be assured by continuous maintenance of all tank components, close scrutiny of the day to day operation of production facilities, and by following sound specifications when these first two items are overlooked and major repairs are required. 4 figs.

6875 (IT–CE-02787, pp. 26) **Overview on problems of pond construction.** Haycock, D.H. (Conestoga-Rovers and Associates Ltd., Waterloo, ON (Canada)); Turchan, G.T.; Ruminsky, S.T. Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

Petroleum exploration and production (EP) produces a variety of wastes that may adversely affect the natural environment if the wastes are not properly handled, stored, or disposed. The identified types of EP wastes include drilling wastes, produced waters, and associated wastes. Historically, it has been the EP industry's practice to dispose of these wastes as close to the point of generation as possible with consideration for environmental requirements, regulatory requirements, landowner requirements, and cost factors. An integral part of the management of these wastes has included the use of wastewater ponds. Increasing public concern with respect to the impact of industry on the environment has resulted in more stringent regulations to protect the environment. A review is given of the problems associated with the various pond liner systems that have historically been used by industry. Proper construction of pond liner systems for use in the petroleum industry requires special attention to liner designs, construction details, and quality assurance. 23 refs., 3 figs., 3 tabs.

6876 (IT–CE-02787, pp. 20) **State-of-the-art techniques for effective zone isolation in injection wells.** George, C. (Halliburton Services, Calgary, AB (Canada)); Leinan, A. Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

This paper addresses the basics of primary cementing as well as the special products and processes found to be most applicable to the specialized requirements of injection well cementing, squeeze cementing for remedial purposes, and job simulation to help the planner design the ideal cementing operation. A job report from a Canadian injection well cement is presented, along with a discussion of procedures that could be used to enhance the example operation. It is concluded that since zonal isolation is extremely important in injection wells, a good primary cement job can eliminate expensive remedial work. An illustration of cementing procedure and other equipment are also included. 5 refs., 10 figs.

6877 (IT–CE-02787, pp. 17) **Waste injection well annulus pressure monitoring.** Gray, J.L. (Engineering Enterprises, Inc., Norman, OK (USA)); Syed, T. Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

The underground injection of fluids via injection wells for the purpose of waste disposal can pose a potential threat to groundwater. However, this threat can be significantly reduced with proper well construction, operation, and monitoring procedures. This paper discusses the technical aspects of annular pressure monitoring, including tubing-packer completions, packerless (fluid seal) completion, limitations of annular pressure monitoring, and methods and equipment used to monitor the annulus pressure of injection wells. Factors that can affect the interpretation of annular pressure monitoring data include injection fluid temperature and pressure fluctuations, well configurations, geothermal gradients, and heat exchange coefficients between fluids, tabulars, and cement and formations penetrated. Ideal implementation of annulus pressure monitoring requires continuous monitoring of annular pressure, injection, fluid temperature and pressure, and ambient temperature. 4 refs., 5 figs.

6878 (IT–CE-0 787, pp. 15) **In situ ground water bioremediation.** Ward, C.H. (Rice Univ., Houston (Texas)); Thomas, J.M. Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

The paper gives an introduction to in-situ groundwater bioremediation which involves stimulation of the indigenous subsurface microflora to degrade contaminants. The authors observe basically five steps in the in-situ biorestoration process: determining the presence of contaminant-degrading microorganisms; conducting a thorough site investigation; recovering free products, when applicable; conducting laboratory studies to determine the nutrient requirements of the indigenous microflora and compatibility of the nutrients with subsurface materials, and designing and implementing the system. The authors observe that mathematical models can be used to design the injection and production system and predict the progress of the bioremediation. Two such examples, BIOPLUME and BIOPLUME II, which have been developed at the Rice University to predict transport and biodegradation of groundwater contaminants as described. 30 refs.

6879 (IT–CE-02787, pp. 34) **Assessment of some techniques for monitoring class I (hazardous-waste) injection wells.** Moffett, T.B. (Univ. of Alabama, Tuscaloosa, AL (USA)); Mankin, C.J.; Silver, C.A.; Whitaker, L.E. Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

The new stringent requirement imposed by the United States Environmental Protection Agency for Class I (Hazardous Waste) injection wells increased the responsibility of operators and regulators of hazardous-waste injection wells to utilize monitoring programs that could effectively and efficiently detect leakage of hazardous constituents from the injection zone. This paper emphasizes that one of the most important aspects of designing a monitoring program is selecting the optimum horizontal distance from the injection well to a monitoring well(s). Interpretation of pressure losses associated with injection wells indicates a radius of maximum pressure corresponding to a 50% decline in pressure outward from an injection well generally is within an area of about 800 ft from injection wells. The greatest potential for leakage through confining zones at facilities with single injection wells occurs within the radius of maximum pressure and provides guidance for placement of monitorng wells. Three scenarios are constructed of water-quality monitoring that are applicable to monitoring injection well facilities. Statistical methods are provided for interpreting data from the three scenarios so that leakage, if any, into confining and overlying zones and arrival of waste fronts in injection zones can be detected. Recommendations are provided for reporting and analyzing water-quality and pressure data from monitoring programs. 14 refs., 2 figs., 1 tab.

6880 (IT–CE-02787, pp. 22) **Current and state-of-the-art techniques for mechanical integrity testing of underground injection wells.** Thornhill, J.T. (U.S. Environmental Protection Agency, Ada, OK (USA)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

Underground injection control regulations of the U.S. Environmental Protection Agency (EPA) require that all injection wells demonstrate mechanical integrity, which is defined as no significant leak in the casing, tubing, or packer, and no significant fluid movement into an underground source of drinking water through vertical channels adjacent to the injection well bore. These requirements were tested in a three phased research project in 1981. Although this report represents the state-of-the-art for determining mechanical integrity for class II wells, the technology described may be applied to other classes of injection wells. The research facilities described here offer industry state regulatory agencies and EPA a unique capability to test and evaluate a variety of methods for determining mechanical integrity. 12 figs., 1 tab.

6881 (IT–CE-02787, pp. 21) **API environmental guidance on management of onshore drilling waste.** Springer, N.K. (Exxon Production Research Co., Houston, TX (USA)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

This paper is an extract from the publication API Environmental Guidance Document: Onshore Solid Waste Management in Exporation and Production Operations. It summarizes environmental guidance on management of onshore drilling waste. It identifies waste generated in drilling operations and categorises them as primary drilling waste, reserve pit waste, and drilled rig waste or contaminated soil. For all wastes, a hierarchy of management options is established: source reduction, recycling, treatment, and disposal. For each category and subcategory of wastes, management and disposal alternatives are presented. Guidance on implementing treatment and disposal of waste is also offered.

6882 (NTRR–89-03925) **Inventory of and recycling alternatives for waste liquid petroleum in the Northwest Territories.** Northwest Territories Dept. of Renewable Resources, Yellowknife, NT (Canada). Feb 1987. 86p. (MICROLOG–89-03925). Available from PC Northwest Territories. Dept. of Renewable Resources, P.O. Box 1320, Yellowknife, NT, CAN X1A 2L9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

The Northwest Territories produce a substantial amount of waste liquid petroleum. A total of ca 1.8 million l/y are produced, of which over 800,000 are currently not used for dust suppression, fire fighting exercises, or as fuel. A variety of processes for re-refining waste oils exist and have been successfully applied in Canada. In addition, the burning of waste oil for heat recovery is feasible. A concern may be the emission of lead pollutants into the atmosphere, but lead is being phased out as a gasoline additive and even now over 90 vol % of waste oils in the Territories are reasonably free of lead contamination. A waste-oil fired municipal water heating plant is being built in Hay River. It includes fuel pre-processing and a pollution monitoring program. Three potential alternatives for the disposal of waste oil were examined: re-refining in southern Canada; building a local re-refinery; and burning the waste oil as a heating fuel. Only the third alternative shows promise of being economically viable. Re-refining the waste oil in southern Canada may become economically feasible if the costs of transport to the re-refinery are substantially reduced and the price paid for the waste oil rises considerably. This is not expected to happen in the next 20 years. Building a local re-refinery is not economically viable at current waste oil quantities. A waste oil increase of at least one order of magnitude, not anticipated in the foreseeable future, is required before a re-refinery could operate profitably in the Territories. The greatest potential for waste oil increases comes from oil exploration in the North, but no substantial activity is anticipated by the oil companies for at least 4-5 years. 10 refs., 1 fig., 9 tabs.

6883 (ORNL/TM–11355) **Focused feasibility study of Forbes Field Air National Guard Base, Topeka, Kansas.** Garland, S.B. II (Oak Ridge National Lab., TN (USA)); Morrissey, C.M.; Cronk, T.A. Oak Ridge National Lab., TN (USA). Oct 1989. 43p. Sponsored by U.S. Department of Defense; U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. Order Number DE90004387. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This focused feasibility study (FFS) for the Forbes Field Air National Guard Base (ANGB), Topeka, Kansas, has been prepared as part of Phase II of the Installation Restoration Program (IRP) of the US National Guard Bureau (NGB). The Remedial Investigation characterizes the contaminants and recommends remedial action. The Remedial Investigation Report (RIR) found fuel present in the subsurface environment at Forbes Field ANGB but did not recommend feasibility studies be conducted because the tight clay soils prevent leaching of the fuel to the groundwater or off site. However, the RIR recommended that no excavations take place near the fuel laterals unless a plan is developed to manage the contaminated soil. 12 refs., 6 figs., 5 tabs.

0209 Environmental Aspects

6884 (CANWEC–CE-02832, pp. 13) **Oil field development under extremely hostile conditions and protection of the environment: Report 2.3.8. .** Khristianovich, S.V. (USSR Academy of Sciences (USSR)); Shemyakin, E.E.; Surguchev, M.L.; Filanovsky, V.Y.; Zheltov Y.V.; Chernitsky, A.C. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02832). In *Energy for tomorrow. Division 2: Energy and the environment: Session 2.3: Environmental concerns: The role of technology.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper deals with the environmental impact of oil field development activity, particularly in USSR. The pollution caused by oil spills, both in offshore production and seaborne carriage of oil is described. It deals with important statistics of land acquisition in connection with oil-field development. The oil and gas industry accounts for not more than 8 to 10% of the total industrially induced pollutants released into the atmosphere. The extent of the environmental impact of man-induced oil field development on different sizes of oil fields is described. The oil-field, Tenguiz, USSR, and its geological features in relation to three types of reservoirs are studied, and the laboratory tests results are included. The findings of this investigation of the man-induced geodynamic processes in the Tenguiz field and their environmental impact, may prove of significance to the world petroleum industry in that development projects elsewhere may face similar problems. Overcoming these problems is essential for future ecologically sound oil field developments.

6885 (IT–CE-02787) **Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.** Info-Tech, Calgary, AB (Canada). 1989. vp. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

Papers presented at this conference may be grouped into eight subject areas; management of drilling wastes; deep well injection of wastes; waste containment; above ground tank management; site management and spill prevention; monitoring and detection; recovery of organic contaminants; and treatment technology for soil and groundwater contamination. Separate abstracts have been prepared for 25 papers.

6886 (IT–CE-02787, pp. 18) **Procedures used to prevent or minimize pipeline spills.** Wishart, D.M. (Interprovincial Pipe Line Co., Edmonton, AB (Canada)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

The paper briefly outlines some of the procedures used to prevent or minimise pipeline spills. Specifically, low vapor pressure liquid pipelines constructed on land are addressed. It does not represent operations of all pipeline companies but rather describes the best present technology. The author emphasizes that pipeline design involves calculated selection of materials to account for typical and unusual loadings and influences. The paper describes in detail the design parameters, including route location, materials selection, sectionalizing valves, and corrosion prevention. The discussion of construction procedures covers material quality assurance, construction inspection, radiographic inspection, pipe coating, pressure testing and caliper survey. The discussion of operating procedures includes pipeline control, corrosion protection monitoring, pipe deformation, metal loss surveys, detecting cracking defects, leak detection, etc. Finally the paper covers the causes of failure. The author concludes that the pipelines have proven to be very reliable means of transporting hydrocarbons and future advances in technology hold promise for an ever improving performance record. 3 figs

6887 (IT–CE-02787, pp. 20) **A novel approach to invert oil mud formulations: VERSACLEAN-K.** Rines, S.P. (M-I Drilling Fluids Co., Houston, TX (USA)); Hoskin, S.J. Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

A new invert emulsion drilling fluid, VERSACLEAN K, is discussed. This fluid is composed of a low aromatic mineral oil and a new internal phase. The water activity of the internal phase is controlled with a new compound, EMI 161. The flexibility of the drilling fluid allows it to be substituted for conventional diesel oil/$CaCl_2$ oil muds to lessen the environmental impact upon disposal. Microtox analysis of VERSACLEAN K and other drilling fluids are described. This method measures the impact of a water soluble extract on the emission of fluorescent light from a bioluminescent marine bacteria. The environmental impact analysis results have demonstrated that the major factor in determining the level of toxicity for the VERSACLEAN K system is the mineral oil used in the formulation. Conclusions and data of the effect of oils, additives, and internal phases on the toxicity of drilling fluids are described in detail. 9 refs., 1 fig., 1 tab.

6888 (IT–CE-02787, pp. 30) **The use of soil vapor contaminant assessments to aid in the delineation of subsurface petroleum spills.** Wolf, D.M. (EA Engineering, Science, and Technology, Inc., Sparks, MD (USA)); Quinn, L.S.; Reisinger, J. II. Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

This paper traces the history of soil vapor contamination assessment (SVCA) as an effective tool to aid in assessing subsurface petroleum spills, and gives the theory of SVCA. An overview of the applicability, procedures and data interpretation is discussed. Site specific conditions and chemical composition of the subsurface spill is taken into consideration. It infers that failure to recognise and understand the various influencing factors surrounding an SVCA could lead to misinterpretation of site conditions. Procedures for sampling and analysis of soil vapor are addressed. Data interpretation must be viewed with respect to a given spill and investigative objectives. The benefits and limitations of soil vapor contaminant assessment are addressed. It includes five figures and chromatograms of soil vapor samples. 5 refs., 6 figs.

6889 (UCRL–21216) **Effects of the Shell Oil spill on hydrocarbon metabolism in the staghorn sculpin Leptocottus armatus: Pilot and reconnaissance study for the Shell Oil spill assessment and recovery monitoring environmental effects program.** Spies, R.B. Lawrence Livermore National Lab., CA (USA). Jun 1989. 40p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. Order Number DE90003918. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

On 23 April 1988, about 400,000 gallons of San Joaquin Valley crude oil (SJVC) were released from Shell Oil into Peyton Slough. The oil flowed down Peyton Slough, and some of it reached Suisun Bay where winds and tidal currents distributed it over much of the water surface of eastern Carquinez Strait and western and southern Suisun Bay. To determine if the Shell Oil spill had a sublethal effect on fish in Peyton Slough and the nearby areas of Carquinez Strait and Suisun Bay that were exposed to the oil, we measured the capacity of the staghorn sculpin Leptocottus armatus to metabolize hydrocarbons. This species was collected from a series of sites that were most likely to be affected by the spill: within Peyton Slough, offshore of the mouth of Peyton Slough, and at the West Martinez mudflat. Collection sites that were somewhat further from the spill, but may have been affected by the spill included the following stations: near the Mothball Fleet, near Point Edith, and in Southampton Bay. A collection site in northern San Francisco Bay near several ship-refueling docks, contaminated by hydrocarbons from local activities, served as a comparison to the stations near the oil spill. Tomales Bay, minimally impacted by man's activities, served as a reference collection site for the urbanized San Francisco Bay system. The enhancement of hydrocarbon-metabolizing capacity in fish exposed to petroleum hydrocarbons, including those at the spill site, demonstrate a biologically detectable effect of such exposure.

0210 Legislation and Regulations

Refer also to citation(s) 7726

6890 (ERCB–D89-8) **Strathfield Oil and Gas Ltd. applications for well licences. Provost field.** Energy Resources Conservation Board, Calgary, AB (Canada). 1989. 18p. (CE–02809). Available from Energy Resources Conservation Board, 640-5th Ave. SW, Calgary, AB, CAN T2P 3G4. Prices: N/C.

Strathfield Oil and Gas applied to the Energy Resources Conservation Board of Alberta for licenses to drill wells in order to obtain production from the Lower Cretaceous Mannville Group in the Provost Field. A hearing was conducted to consider the following issues related to the application: the need for the wells and the well spacing, the proposed development plan, environmental impacts, future production operations, and communication. The proposed development plan involved directional drilling of a number of wells from one pad, which would minimize many of the impacts considered in the hearing. These impacts included surface water and groundwater impacts, air quality impacts from possible gas emissions from the drill site, and land use and habitat impacts in an area characterized by susceptibility to wind erosion. After consideration of the presentations of the applicant and the intervener at the hearing, license applications were approved for 13 of the 14 wells involved. 2 figs., 1 tab.

6891 (ERCB–G-35) **Guide for completing a production facility application.** Energy Resources Conservation Board, Calgary, AB (Canada). Mar 1988. vp. (CE–02806). Available from Energy Resources Conservation Board, 640-5th Ave. SW, Calgary, AB, CAN T2P 3G4. Prices: N/C.

In Alberta, all facilities, other than gas processing plants, constructed for the purposes of receiving production from a well or wells for treating or processing prior to disposition require approval of the provincial Energy Resources Conservation Board. Such facilities include all oil batteries, gas batteries, groups of gas or oil wells, including single oil- or gas-well batteries, and compressor stations.

This guide explains in detail how to complete the form and prepare and application for approval of a production facility. The sections of the guide are arranged in the same order as the sections of the application form. Definitions are included as necessary. A discussion of well testing frequency is appended.

0220 Transport, Handling, and Storage

Refer also to citation(s) 6885, 8164

6892 (NDA–88-063) **An assessment of the hydrocarbon and compressed air storage potential of Nova Scotia salt deposits: A summary.** Nolan, Davis and Associates (N.S.) Ltd., Halifax, NS (Canada). [1988]. 31p. (MICROLOG–89-04003). Available from PC Nova Scotia Dept. of Mines and Energy, 1701 Hollis St., PO Box 1087, Halifax, NS, CAN B3J 2X1; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $3.00 CAN; MF $10 CAN.

A study has been made to determine the potential for using Nova Scotia's salt deposits as energy-related storage sites. The specific energy-related products of interest were identified to be crude oil petroleum gases, natural gas, compressed air, and hazardous waste. The report discusses the history of underground storage, the geology of salt in Nova Scotia, cavern development and operation (with emphasis on the storage depth, which depends upon pressure requirements), geotechnical considerations and cavern design, environmental considerations (the most difficult problem being the disposal of brines), site selection, and economics. Twenty-seven known salt deposits and occurrences in five geographical areas of Nova Scotia were initially examined as potential storage cavern sites. Based on a list of six criteria, seven sites have been chosen and ranked as presently showing the most promise; the geological data about these sites are summarized in the appendix to the report. Various deposits were eliminated due to insufficient data; consequently, with the future acquisitions of relevant data, the ranking of the deposits could change. In conclusion, the present study has indicated the feasibility of developing salt caverns in Nova Scotia for large-scale energy-related storage purposes.

0230 Properties and Composition

Refer also to citation(s) 6686, 6715, 6843

6893 (FSJ–8901, pp. 268-271) **Chemical Structure distribution of crude oil for oil-oil correlation study by means of HPLC-GC/MS.** Bakr, M. (Hokkaido Univ., Faculty of Engineering, Sapporo, Japan); Yokoyama, S.; Sato, M.; Sanda, Y. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

The distribution of chemical structure of Khafji crude oil in range of 200-400^{0}C was studied. Saturated hydrocarbons are the major group (88.12 wt%), while iso- and cycloalkanes which are urea nonadduct, predominate. Aromatic fraction represents 8.79 wt%. Khafji crude oil is rich in sulphur content and most of the sulphur is concentrated in the aromatic portion (7.31 %). In the aromatic hydrocarbons, naphthalenes, diphenyls, and phenanthrene predominate, while the more condensed aromatics are minor. Sulphur compounds are assumed to benzo, dibenzo and phenanthrothiophenes, total thiophene derivatives average 48.91 % of the aromatic fraction. Dibenzothiophenes are the major group of thiophenic compound in Khafji crude oil indicating that this oil is mature one. The n-alkanes are present in a lower concentration (7.72 %) relative to the iso- and cycloalkanes (92.28 %), indicating that some biodegradation has been taken place. The abundance of the n-alkanes, iso- and cycloalkanes increase as a function of molecular weight reaching a maximum at the range of C_{15}-C_{20}, then decrease regularly. 3 refs., 4 figs., 3 tabs.

6894 (FSJ–8902, pp. 279-282) **Aromatic sulfur compounds in crude oil.** Bakr, M. (Hokkaido Univ., Faculty of Engineering, Sapporo); Yokoyama, S.; Sato, M.; Sanada, Y. Fuel Society of Japan, Tokyo (Japan). 10 Nov 1988. In *Proceeding of the 25th Coal Science Conference (1988).* Order Number DE90724915. Available from NTIS (US Sales Only), PC A13.

Condensed thiophenes(PASHs) were isolated from aromatic concentrate of crude oil using ligand exchange chromatography(LEC). PASHs constitute the major part of organic sulfur compounds in crude oil and other fossil fuels. Therefore knowledge on their chemical structure is useful for the effective use of fossil fuels. In this study, preliminary results of a research to characterize the chemical structure of PASHs in crude oil were outlined. Two fractions were collected; the first(Fr-A) includes all the hydrocarbons plus PASHs containing terminal thiophene ring, while the second(Fr-B) includes PASHs containing internal thiophene ring. Fr-B was further fractionated according to the number of aromatic rings into three subfractions. Each subfraction was studied by GC and GC/MS. Alkylated benzo, dibenzo, and benzonaphthothiophenes were the major compounds detected. Mass fragmentograms showed loss of S and CHS. Highly alkylated PASHs showed extended chain alkylation and avoided loss of S or CHS. 3 refs., 1 fig.

6895 (SI-R–860612-2) **Oil identification - phase 2: Report from intercalibration of GC/MS analysis in the Nordic countries.** Sjoegren, C.E. Senter for Industriforskning, Oslo (Norway). Apr 1988. 145p. (In Norwegian). Order Number DE90728247. Available from NTIS (US Sales Only), PC A07/MF A01.

The investigation of the GC/MS-analyses shows good repeatability within each of the Nordic laboratories. Due to large differences in instrumentation an equally satisfactory reproducibility between the laboratories was not obtained. When using GC/MS in an actual oil identification situation all samples, including both the oil spill and the suspected sources, should therefore be analysed in the same laboratory using the same equipment. This allows each laboratory to optimize the analytical conditions to their specific instrumentation. 4 appendices describing instruments, analytical conditions and calibration results. 14 tables, 170 figures.

0250 Combustion

Refer also to citation(s) 6814, 6869

6896 (NAL-TR–1001) **Burning rate constant of fuel droplet under high pressure.** Takahashi, Mamoru; Niioka, Takashi; Sato, Jun'ichi; Yamakawa, Masanori. National Aerospace Lab., Chofu, Tokyo (Japan). Oct 1988. 12p. (In Japanese). Order Number DE89910193. Available from NTIS (US Sales Only), PC A03/MF A01.

This report, having first explained the theoretical background of problematic points in the combustion of fuel droplet under high pressure and perused the experimental result under high pressure environment, then explained the experiment with high density hydrocarbon and elucidated problematic points as rocket fuel. The various phenomenon in combustion science is based on the combustion of droplet, which however has many unknown points, in behavior under high pressure environment to be the most important information. While the theoretical background can no longer be understood by the mere classical analysis. Therefore, the ignition at its very moment was observed through the image on monitor television of droplet combustion made, by the same experimental method as the past one. Heptane and hexadecane, and high density hydrocarbon were tested in high pressure air, and high pressure air and oxygen, respectively. As a result, hydrocarbon fuel conformed to d^2-law,even in the high pressure atmospheric air, with the time decrease in square of droplet diameter. Heptane and hexadecane were understood to increase, with pressure, in burning rate constant in air, and hydrocarbon was also done to be at the same level in burning rate as heptane and hexadecane. 23 refs., 21 figs., 1 tab.

6897 (UBA-FB–87-038) **Dedusting of heavy oil furnaces with filter separators.** Luetzke, K.; Wilkes, R.; Stulgies, A. Rheinisch-Westfaelischer Technischer Ueberwachungs-Verein e.V., Essen (Germany, F.R.). Zentralabteilung Emissionsmessungen; Umweltbundesamt, Berlin (Germany, F.R.). 1 Oct 1987. 316p. (In German). Contract UFOPLAN-Nr. 10407102. Available from Copy held by UB/TIB Hannover.

A filtering separator with glass cloth bags of the type 'bag filter with back-purging' was tested in a pilot plant on an industrial steam boiler fired with heavy oil with regard to the plant-dependent operation conditions. By stepwise alteration of the operating parameters

the high stresses on the filter material by soot, acid and temperature change to be expected for oil firing, were adjusted in 5 test series; the operational behaviour of the filter plant was examined under practice conditions. Finally the pilot filter plant was integrated in the automatic control of the firing plant for 14 months of continuous operation and tested under the conditions of taking over the total flow volume. The characteristic values of the filter plant were determined by a parallel measuring programme. On condition that the structural and operational requirements are met, the filtering separator is suited for the dedusting of waste gases from heavy oil furnaces. (orig.) With 30 refs., 118 tabs., 41 figs.

6898 (VTT-TUTK–638) **Numerical modelling of combustion on furnaces.** Kjaeldman, L. (Valtion Teknillinen Tutkimuskeskus, Otaniemi (Finland). Ydinvoimatekniikan Lab.). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). Aug 1989. 72p. (In Finnish). Order Number DE90728181. Available from NTIS (US Sales Only), PC A04/MF A01.

The report presents work done at Technical Research Centre of Finland to improve the abilities to use computational fluid dynamics to analyze furnace processes of practical interest. Models for spray and dust combustion were implemented to the PHOENICS-code, which was used for all computations. The applications included spray combustion of kerosene and light oil, and staged combustion of heavy oil with air and fuel (natural gas) staging in single burner research furnaces with fuel power between 200 kW and 6 MW. In addition, peat dust experiments in a 5 MW research furnace were simulated. The agreement between the computations and experiments was in generally good for heat transfer rates and local conditions in the end part of the furnace in the spray combustion cases. In the near burner region, where the influence of the inflow conditions is large, the agreement was moderate. For peat dust combustion the agreement between the computed and measured values was good in the near burner and far field regions for three investigated cases with different fuel power or air staging.

6899 **Acoustooptic spectrometer system used to monitor combustion processes.** Bardash, M. (Cornell University, School of Electrical Engineering, Ithaca, New York 14853 (US)); Wolga, G.J. *Applied Optics (USA)*, 28(20): 4279-4285 (15 Oct 1989).

An optical system using a tunable acoustooptic filter to measure the temperature and partial pressures of CO and CO_2 in combustion gases has been designed and operated. The system measures the IR absorption over a linear path through the combustion products from several lines of the vibration–rotation band of CO at 4.7 μm. The temperature and partial pressure of CO are then calculated using these data. The IR absorption due to the asymmetric stretch of CO_2 is then measured. The entire system, under computer control, is self-calibrating and is well suited for remote process control use.

03 NATURAL GAS

Refer also to citation(s) 6823, 6827

0303 Drilling, Production, and Processing

Refer also to citation(s) 6834, 6838, 6839, 6840, 6845, 6908, 6918, 8190

6900 (IT–CE-02785, pp. 21) **Sulphur plant recovery optimization.** Sames, J.A. (Western Research, Calgary, AB (Canada)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8906262–: Conference on gas plant optimization, Calgary (Canada), 7 Jun 1989; CE–02785). In *Is your plant in midlife crisis?*. Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

Obtaining the most sulfur from a modified-Claus plant is a task that requires an in-depth understanding of the process and its configuration alternatives, coupled with a method of evaluating plant performance. The incentive for plant optimization is provided by the fact that marginal increases in sulfur production results in significant reductions in sulfur emission. Optimization to minimize the plant emission can be carried out during all phases of the design and operation of a modified-Claus plant. The procedures used and effects gained are discussed in detail. 13 refs., 5 figs.

6901 (IT–CE-02785, pp. 9) **Plants on auto pilot.** Cushon, G.R. (Shell Canada Ltd., Calgary, AB (Canada)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8906262–: Conference on gas plant optimization, Calgary (Canada), 7 Jun 1989; CE–02785). In *Is your plant in midlife crisis?*. Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

In the next 10 to 20 years, there is potential for a new automated operating environment in gas plants to evolve. Part of this environment will involve the integration of process control and information systems. It could then evolve to a totally automated operation where extensive use of automation technology would lead to a largely unmanned operation. Safety, the environment, people, and regulatory requirements will affect the degree to which total automation can be implemented. Management of organization and cultural issues would likely be an even more significant focus in the future. Key to achieving plants on auto pilot will be the vision supporting the business strategies that are established and the resultant automation strategies. Management of change will be a key factor in the future. 2 refs.

6902 (IT–CE-02785, pp. 15) **Adding process controls.** Bianchin, E.S. (Fisher Controls Co. of Canada, Cambridge, ON (Canada)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8906262–: Conference on gas plant optimization, Calgary (Canada), 7 Jun 1989; CE–02785). In *Is your plant in midlife crisis?*. Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

Distributed control systems (DCS) have been enhanced since their introduction in the late 70s. Today's technology, together with the current business situation, has led to a new approach to adding process controls. The DCS is no longer purchased for control only, but rather it is a vehicle or platform for controlling, collecting, presenting, manipulating, and transmitting data. It forms a key element, together with human resources and quality, in what is called an integrated manufacturing strategy (IMS). This paper shows how the modern DCS has evolved to meet the requirements of IMS. 1 fig.

6903 (IT–CE-02785, pp. 16) **A survey of gas flaring in Alberta.** Reid, C. (Titan Projects, Ltd., Calgary, AB (Canada)); Deboeck, B. Info-Tech, Calgary, AB (Canada). 1989. (CONF-8906262–: Conference on gas plant optimization, Calgary (Canada), 7 Jun 1989; CE–02785). In *Is your plant in midlife crisis?*. Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

As a result of concerns about the environmental acceptability of flaring, a survey of current oil and gas industry flaring practices was undertaken. Questionnaires were used to obtain data on 318 of an estimated 2500 flares in Alberta. Data collected pertained to the basic facility, details of the flare system, and operations and maintenance aspects. Site visits were also conducted in order to verify and augment data. The data base was analyzed to reveal trends with respect to system details, operating procedures, operating experience, maintenance, complaints, and performance. 4 tabs.

6904 (IT–CE-02785, pp. 19) **Sulphur recovery.** d'Haene, P.E. (Quantel Engineering, Calgary, AB (Canada)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8906262–: Conference on gas plant optimization, Calgary (Canada), 7 Jun 1989; CE–02785). In *Is your plant in midlife crisis?*. Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

Sulfur recovery has seen exciting new developments over the past 20 years in Alberta and will see even more innovative changes in the future. This paper describes some of these developments as well as upcoming technologies now available but not yet in use in Alberta. Included are descriptions of processes used today, such as: Modified Claus, Sub-dew point, TGCU, and LOCA. Also included are new processes such as Recycle Selectox, Superclaus, Oxysulfur, BSR/Selectox, MODOP, sulferox, and oxygen enrichment. Sulfur degasification and Energy Resources Conservation Board guidelines are also discussed. 13 figs., 1 tab.

6905 (IT–CE-02785, pp. 21) **Optimization of liquid recoveries in operating plants.** Lim, Y.C. Info-Tech, Calgary, AB (Canada). 1989. (CONF-8906262–: Conference on gas plant optimization, Calgary (Canada), 7 Jun 1989; CE–02785). In *Is your plant in midlife crisis?.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

This paper deals with the opportunities available to the plant operators to optimize the liquid recoveries of their operating plants by changing the processing conditions, maximizing the use of equipment installed and implementing minor process modifications. Significant process design efforts are spent in the beginning phase of a project to establish an optimum process scheme and operating conditions. More often than not, the operating plant encounters significant changes in the processing requirements during the life of the plant. These changes necessitate further optimization of process conditions in order to maximize the plant liquid recoveries. Advantages can also be taken of the design allowances normally provided in mechanical equipment such as heat exchangers and compressors to improve liquid recoveries. Process modifications involving minor piping changes can also lead to significant improvement in liquid recoveries. 4 figs.

6906 (IT–CE-02785, pp. 12) **Nevis: The final years of it's life.** Taylor, J.M. (Chevron Canada Resources, Red Deer, AB (Canada)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8906262–: Conference on gas plant optimization, Calgary (Canada), 7 Jun 1989; CE–02785). In *Is your plant in midlife crisis?.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

The technical solutions and motivational aspects of turning down a major sour gas plant are discussed. Problems of turndown discussed include reduction of plant pressure, elimination of surplus equipment, and the special problems associated with the sulfur plant. The Chevron Canada Resources operated Nevis Operators Committee plant case history is referenced. Included are the Nevis gas composition and turndown modifications. 3 figs., 4 tabs.

6907 (IT–CE-02785, pp. 10) **Opportunities for optimization of new gas plants.** Coady, A.B. (Delta Catalytic Corp., Calgary, AB (Canada)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8906262–: Conference on gas plant optimization, Calgary (Canada), 7 Jun 1989; CE–02785). In *Is your plant in midlife crisis?.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

This paper is intended to address the important issues that face the gas processing industry and how we can best manage our resources to achieve the least capital cost and least operating cost for gas processing facilities while maintaining the integrity of the environment in which the plant must coexist with its surroundings. The optimization of process design, plant layout, equipment selection, and construction methods are explored for new plant facilities. The relationship of these factors as they affect the economics and environment are evaluated and the major advantages for constructing new plant facilities as opposed to expanding older plants are identified. For comparable plant designs, it is shown that lower capital and operating costs can be achieved with optimized new plants as compared to expansion of existing plants.

6908 (IT–CE-02787, pp. 14) **Environmental audits of gas processing facilities.** Holliday, G.H. (Holliday Environmental Services, Inc., Tomball, TX (USA)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

This paper discusses environmental compliance review philosophy, procedures, findings and remediation with particular emphasis on gas processing facilities. The petroleum extraction industry uses environmental audits to assess compliance with the increasingly stringent regulations and to train middle management, engineers and field personnel in environmental compliance. Additionally, audits are used to assess potential problems and costs associated with acquisition of new facilities. Gas plants present a particular challenge because of the complexity of the operations and the variety of potential problems, i.e., releases, spills, ponds, and air and water discharges. Experience indicates the most prevalent environmental problems at gas plants are air related. However, spills, under-ground storage tanks and surface pits have caused demonstrable problems. Any potential environmental problems revealed by the audits, discussions and site reviews are investigated in detail for compliance. The results of investigations showed that the severity of environmental penalties and plethora of regulations requires constant vigilance within production operations to assure compliance. Additionally, there is need to train plant operating personnel to be alert to regulations which require permits for plant modifications, periodic inventories, and good record keeping.

0304 Products and By-Products

6909 (IT–CE-02785) **Is your plant in midlife crisis?.** Info-Tech, Calgary, AB (Canada). 1989. vp. (CONF-8906262–: Conference on gas plant optimization, Calgary (Canada), 7 Jun 1989; CE–02785). Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

This conference focused on gas plant optimization and process control. It was divided into four sessions related to the following topics: the plant life cycle and opportunities for optimization, process unit optimization, optimizing for environmental concerns, and the future of process controls. Separate abstracts have been prepared for 9 papers from this conference. 21 refs., 23 figs., 5 tabs.

0305 Health and Safety

Refer also to citation(s) 6918

0306 Economic, Industrial, and Business Aspects

Refer also to citation(s) 6863, 6867, 6918, 6926, 7728, 7738

6910 (ESC–CE-02783) **Assessing the challenge ahead.** Economics Society of Calgary, AB (Canada). 1988. vp. (CONF-8811296–: 4. annual Canadian natural gas marketing conference, Calgary (Canada), 16 Nov 1988; CE–02783). Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

This conference covers the challenge in marketing natural gas; natural gas supply and demand; deregulation from the producer's distributor's, and consumer's point of view: the pipeline network and export projects; and the marketing and regulation outlook to 1995. Separate abstracts are given 5 of papers

6911 (ESC–CE-02783, pp. 4) **Domestic market demand.** Lougheed, R.S. (Consumers Gas Co. Ltd., Toronto, ON (Canada)). Economics Society of Calgary, AB (Canada). 1988. (CONF-8811296–: 4. annual Canadian natural gas marketing conference, Calgary (Canada), 16 Nov 1988; CE–02783). In *Assessing the challenge ahead.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

This paper gives a brief overview of market demand in Canada for natural gas. It also covers the need for more pipelines to provide a secure supply in eastern Canadian markets, and the transition of many customers to the direct purchase method of acquiring their gas supply. New markets as represented by co-generation and/or combined cycle generation of electricity and the use of natural gas in transportation sector are considered important for the future. The author briefly touches upon the uncertainties of price and supply in the current market and their effect upon consumers.

6912 (ESC–CE-02783, pp. 20) **A review of Canada's present and future supply.** Strom, N.A. (Energy Resource Conservation Board, Calgary, AB (Canada)). Economics Society of Calgary, AB (Canada). 1988. (CONF-8811296–: 4. annual Canadian natural gas marketing conference, Calgary (Canada), 16 Nov 1988; CE–02783). In *Assessing the challenge ahead.* Available

from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

This paper gives a brief overview of Canada's present and future natural gas supply. The subject is presented in 6 parts: an overview of present established reserves and potential future reserves in current Canadian conventional producing areas; the status of export permits; presently established and potential future reserves that would be available from Canadian frontier areas; a review of past 20 years of the pattern of acquisition and production; future reserves growth in the conventional area; and possible future patterns of supply from conventional and frontier areas.

6913 (ESC–CE-02783, pp. 12) **Export demand for Canadian gas.** Denhardt, R.C. (Jensen Associates, Inc., Boston, MA (USA)). Economics Society of Calgary, AB (Canada). 1988. (CONF-8811296–: 4. annual Canadian natural gas marketing conference, Calgary (Canada), 16 Nov 1988; CE–02783). In *Assessing the challenge ahead.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

This paper addresses the export demand for Canadian natural gas in light of the United States supply-demand balance, and the Canadian export capacity. An index developed by Jensen Associates is presented which measures the U.S. supply-demand balance, representing the ratio of production to the estimate of deliverability and indexed so that when the ratio equals one there are strong upward pressures on gas prices. Included is a short discussion on export capacity, limited by seasonality and market congestion. Problems and difficulties in the United States which could lead to limitations on Canadian exports are identified.

6914 (IT–CE-02785, pp. 13) **A program to improve plant profitability.** Yarborough, L. (Amoco Canada Petroleum Co. Ltd., Calgary, AB (Canada)); Martin, D.A. Info-Tech, Calgary, AB (Canada). 1989. (CONF-8906262–: Conference on gas plant optimization, Calgary (Canada), 7 Jun 1989; CE–02785). In *Is your plant in midlife crisis?.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

The methodology of a program to improve natural gas processing plant profitability is reviewed, including the major considerations for a successful program. Details on the approach to plants are provided along with some examples of recent improvements. An approach is outlined for improving plant profitability in a situation where two companies have recently merged. 6 refs.

0307 Waste Management

Refer also to citation(s) 6899, 6902, 6903, 6907

0308 Environmental Aspects

Refer also to citation(s) 6885, 6920

0310 Legislation and Regulations

Refer also to citation(s) 6890, 6909, 6927, 7680

6915 (BCUC–89-03683) **In the matter of the Utilities Commission Act, S.B.C. 1980, c. 60, as amended and in the matter of an application and an alternative application by Pacific Coast Energy Corporation for an energy project certificate to construct and operate natural gas pipeline transmission facilities to and on Vancouver Island: Phase 3. Final report.** British Columbia Utilities Commission, BC (Canada). 6 Apr 1989. 85p. (MICROLOG–89-03683). Available from PC British Columbia Legislative Library, Government Documents Division, Parliament Buildings, Victoria, BC, CAN V8V 1X4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

This is the final report of the British Columbia Utilities Commission for applications by Pacific Coast Energy corporation for the provision fo a natural gas pipeline to Vancouver Island. This report considers the Commission's finding on markets, gas supply, and financial matters. The report provides a description of the project; major components of the project structure, including markets, peak shaving requirements, cost of service, gate station revenue, industrial revenue, wheeling agreements, transportation tolls, storage and supply, and a reassessment of facilities and capital costs; financial models; and transportation service alternatives. Conclusions and recommendations covering markets, supply, and financial matters are given. A list of exhibits is also included. 3 figs., 10 tabs.

6916 (BCUC–89-03683) **In the matter of the Utilities Commission Act, S.B.C. 1980, c. 60, as amended and in the matter of an application and an alternative application by Pacific Coast Energy Corporation for an energy project certificate to construct and operate natural gas pipeline transmission facilities to and on Vancouver Island: Phase 1 and 2. Interim report.** British Columbia Utilities Commission, BC (Canada). 14 Mar 1989. 162p. (MICROLOG–89-03682). Available from PC British Columbia Legislative Library, Government Documents Division, Parliament Buildings, Victoria, BC, CAN V8V 1X4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

This is the interim report of the British Columbia Utilities Commission for applications by Pacific Coast Energy Corporation for the provision fo a natural gas pipeline to Vancouver Island. This interim report considers the Commission findings on land and marine facilities and capital costs, including routing, facility design, operational considerations, and facility construction. 2 figs., 15 tabs.

6917 (BCUC–89-03684) **In the matter of the Utilities Commission Act, S.B.C. 1980, c. 60, as amended and in the matter of an application and an alternative application by Pacific Coast Energy Corporation for an energy project certificate to construct and operate natural gas pipeline transmission facilities to and on Vancouver Island: Phase 1, 2 and 3. Executive summary.** British Columbia Utilities Commission, BC (Canada). 6 Apr 1989. 10p. (MICROLOG–89-03684). Available from PC British Columbia Legislative Library, Government Documents Division, Parliament Buildings, Victoria, BC, CAN V8V 1X4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

This executive summary consolidates and highlights the most important findings form the Commission's hearing of the Pacific coast Energy Corporation application to construct and operate a natural gas transmission pipeline to Vancouver Island. The evidence and rationale supporting the Commission's findings are contained in the full report, the interim report provides a detailed review of facilities, capital costs, environmental and socio-economic matters, and the final report reviews the market, gas supply and financial matters. The commission is satisifed that the project is technically feasible and that it can be constructed at a cost close to the $248 million estimated by the proponent. Support for the project was given by forestry and petroleum associations. Long-term air quality benefits and the pollution risks from waterborne fuel oil transport can be achieved with only short-term environmental impact. In order to achieve the projected in-service date of September 1, 1990, construction must begin in early May 1989. Ten recommendations are made by the Commission.

6918 (CIM/S–CE-02846, pp. 12) **Natural gas transportation in Saskatchewan.** Gorr, V.R. (Saskenergy Corp., SK (Canada)). Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

Prior to October 31, 1985 the only place in Saskatchewan where producers could sell their natural gas was to the Saskatchewan Power Corporation (SaskPower) at provincial government regulated prices. The only place consumers could buy natural gas was from SaskPower, again at regulated prices. On October 31, Canada, Saskatchewan, Alberta, and British Columbia signed the Agreement on Natural Gas Markets and Prices to deregulate the Canadian natural gas industry. Deregulation in Saskatchewan was introduced in

two phases. Under Phase I in February 1987, government regulation of prices for gas sold to SaskPower was eliminated. Under Phase II, in October 1987, the merchant and transportation function of SaskPower's natural gas system were separated, allowing consumers to purchase natural gas directly from producers and to only contract with SaskPower for the transportation service. At the same time, the government increased significantly the amount of gas that could be exported from the province. As well as the new transportation policy, which had to be put into place very rapidly to accommodate deregulation, significant physical facilities had to be built to handle the increased requirements for natural gas transportation. In 1988, approximately $91 M was spent on new transmission facilities. The capacity of the system increased by approximately 6.2 M m^3/d. A smaller expansion program was planned for 1989, which should bring on stream an additional capacity of approximately 3.325 M m^3/d. Natural gas well drilling, Saskatchewan natural gas production, employment, and provincial royalty revenue have all increased. Also, due to the rise in activity in the field, the remaining established natural gas reserves have also grown. 7 figs.

6919 (CRPC–89-04192) **A guide to sour gas development and land use planning within the Calgary region.** Calgary Regional Planning Commission, AB (Canada). Sep 1987. 171p. (MICROLOG–89-04192). Available from PC Calgary Regional Planning Commission, Library, 4303-11 St. SE, Calgary, AB, CAN T2G 4X1; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

These guidelines provide general information on the sour gas industry within the Calgary Region, beginning with a definition of sour gas, an inventory of reserves and existing facilities, and including an overview of the market. The guide then explains the purpose and function of wells, pipelines, and processing plants; inspection and monitoring of air, water and soil; lease agreements and landowners rights; nuisance problems associated with such facilities; legislation and policy governing development; human health effects of sulphur dioxide and hydrogen sulphide; hydrogen sulphide exposure and counteracting measures; and land use planning and sour gas development. The document is aimed at municipal councillors, development officers and planners and is meant to be used in conjunction with a companion study on the technical issues which outlines some of the issues and deficiencies related to planning around sour gas development. 9 figs.

6920 (ERCB–D89-1) **Rustum Petroleums Ltd. special gas well spacing: Cygnet area.** Energy Resources Conservation Board, Calgary, AB (Canada). [1989]. 16p. (CE–02801). Available from Energy Resources Conservation Board, 640-5th Ave. SW, Calgary, AB, CAN T2P 3G4. Prices: PRICES UPON REQUEST.

Rustum Petroleums applied before the Energy Resources Conservation Board of Alberta for an order establishing a fracional section in the Cygnet area of the province as a special drilling spacing unit (DSU) for the production of gas from the Glauconitic Sand deposit. A hearing was held to consider matters related to the application. Issues addressed in the hearing included the eligibility of the fractional section in question as a special (in this case, smaller than normal) DSU; the appropriate target area provisions that should apply; the method of determining, and mannery of applying, any penalty or adjustment factors to restrict production rates; and the delineation of the Glauconitic gas pool(s) penetrated by Rustum's well in that section. On the basis of its findings, the Board decided to grant a special DSU for the production of gas from the well located in the fractional section under consideration, with special gas target provisions and production restrictions given. 4 figs.

6921 (ERCB–IL88-9) **Amendement of interim directive ID 87-2: Sour well licensing and drilling requirements.** Energy Resources Conservation Board, Calgary, AB (Canada). 13 Jun 1988. 21p. (CE–02807). Available from Energy Resources Conservation Board, 640-5th Ave. SW, Calgary, AB, CAN T2P 3G4. Prices: N/C.

Replacement pages are provided to amend the Alberta Energy Resources Conservation Board's directive 87-2 which outlined the requirements related to the licensing and drilling of all sour wells, and the special requirements for those wells which require an emergency response plan or are classified as critical sour wells. The changes include: a clarification of expectations regarding the setback distance from a well to any dwelling for the high H_2S release rate wells; specification of accumulator system sizing and function testing requirements in critical sour well applications; adding a new requirement prohibiting drill stem testing of critical sour wells; and clarification of the definition of a public facility.

6922 (ESC–CE-02783, pp. 10) **The 1995 regulatory framework.** Priddle, R. (National Energy Board, Ottawa, ON (Canada)). Economics Society of Calgary, AB (Canada). 1988. (CONF-8811296–: 4. annual Canadian natural gas marketing conference, Calgary (Canada), 16 Nov 1988; CE–02783). In *Assessing the challenge ahead.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

This paper covers the National Energy Board (NEB) regulatory framework expected to be in place in Canada up to 1995. The regulations cover pipeline facilities, both new and additions to existing facilities. Reviews of such facilities are expected to be rigorous, although where modest expansions are involved, review will be less stringent. For new pipelines accessing new sources of supply in the north, a careful review of environmental, socio-economic and right-of-way matters should be expected. By the 1990s all NEB-regulated pipelines should be fully open, after which there will be continued emphasis on efficient regulation and more explicit recognition of the role of competitive market forces. The regulation of exports and imports will consist of a monitoring-only process for short-term gas exports, and the routine use of the 1987 market-based procedures for long-term cross-border sales. With a functioning gas market, exports which do not involve environment or other public interest concerns should receive ready approval. A short biography of the author is included.

6923 (NEB-SS–GH-4-88) **Reasons for decision [in the matter of an application by] TransCanada PipeLines Ltd.** National Energy Board, Ottawa, ON (Canada). Jan 1989. 65p. (CE–02796). Available from National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: N/C.

In October 1988 TransCanada Pipelines Ltd. applied for a certificate for new facilities to expand the capacity of its pipeline system for the 1989/90 contract year. This report gives and overview of the application and considers the Board's findings on supply, requirements of the Canadian and export markets, contracts, regulatory matters, the need for facilities, land use and environmental matters, the retirement of compressors,and the economic feasibility of expansion. The Board awarded the certificate and concluded that the proposed expansion was economically feasible. 1 fig., 6 tabs.

6924 (NEB-SS–GH-4-88F) **Reasons for decision [in the matter of an application by] TransCanada PipeLines Ltd.** National Energy Board, Ottawa, ON (Canada). Jan 1989. 69p. (CE–02797). Available from National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: N/C.

In October 1988 TransCanada Pipelines Ltd. applied for a certificate for new facilities to expand the capacity of its pipeline system for the 1989/90 contract year. This report gives and overview of the application and considers the Board's findings on supply, requirements of the Canadian and export markets, contracts, regulatory matters, the need for facilities, land use and environmental matters, the retirement of compressors,and the economic feasibility of expansion. The Board awarded the certificate and concluded that the proposed expansion was economically feasible. 1 fig., 6 tabs.

6925 (NEB-SS–GHW-1-89-E) **Reasons for decision in the matter of Foothills Pipe Lines (Alta.) Ltd.** National Energy Board, Ottawa, ON (Canada). Jun 1989. 17p. (CE–02774). Available from National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: N/C.

Foothills Pipe Lines (Alta.) Ltd. owns and operates approximately 379 kilometres of pipeline and related compression facilities between the Schrader Creek compressor station facilities of NOVA Corporation of Alberta near Caroline, Alberta and the compressor station facilities of Foothills Pipe Lines (Sask.) Ltd. at the Alberta/Saskatchewan border near Empress, Alberta. This pipeline and related facilities comprise Zone 6 of the eastern leg of Phase I of the

Alaska Natural Gas Transportation System (Prebuild). This document presents a summary of the hearings to remove a bottleneck in the pipeline in Zone 6, which would authorize the construction and operation of the proposed facilities, consisting of decompression/recompression facilities and a new 610-mm outside diameter interconnection with the NOVA pipeline system. The summary provides details of the application, the existing integrated operation and the proposed segregated operation; requirements and facilities including alternatives; the views of the Board; and the decision of the Board. Maps indicate the Prebuild System, the existing pipelines operations, and a location plan of the proposed facilities. A list of submittors is also included. The Board decided that the proposed facilities were in the public interest, and permitted Foothills to include the actual amount of constructing the facilities, up to a specified amount, in its Zone 6 rate base. 4 figs., 2 tabs.

6926 (NEB-SS–GHW-1-89-F) **Reasons for decision in the matter of Foothills Pipe Lines (Alta.) Ltd.** National Energy Board, Ottawa, ON (Canada). Jun 1989. 17p. (CE–02775). Available from National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: N/C.

Foothills Pipe Lines (Alta.) Ltd. owns and operates approximately 379 kilometres of pipeline and related compression facilities between the Schrader Creek compressor station facilities of NOVA Corporation of Alberta near Caroline, Alberta and the compressor station facilities of Foothills Pipe Lines (Sask.) Ltd. at the Alberta/Saskatchewan border near Empress, Alberta. This pipeline and related facilities comprise Zone 6 of the eastern leg of Phase I of the Alaska Natural Gas Transportation System (Prebuild). This document presents a summary of the hearings to remove a bottleneck in the pipeline in Zone 6, which would authorize the construction and operation of the proposed facilities, consisting of decompression/recompression facilities and a new 610-mm outside diameter interconnection with the NOVA pipeline system. The summary provides details of the application, the existing integrated operation and the proposed segregated operation; requirements and facilities including alternatives; the views of the Board; and the decision of the Board. Maps indicate the Prebuild System, the existing pipelines operations, and a location plan of the proposed facilities. A list of submittors is also included. The Board decided that the proposed facilities were in the public interest, and permitted Foothills to include the actual amount of constructing the facilities, up to a specified amount, in its Zone 6 rate base. 4 figs., 2 tabs.

6927 (NEB-SS–RH-2-88) **Reasons for decision [In the matter of an application by] Trans Quebec and Maritimes Pipeline Inc. Application dated 7 July 1988, as amended, for new tolls effective 1 January 1989 and 1 January 1990.** National Energy Board, Ottawa, ON (Canada). Dec 1988. 26p. (CE–02798). Available from National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: N/C.

Trans Quebec (TQM) & Martimes Pipeline Inc. operates a pipeline for the transmission of natural gas from St. Lazare, Quebec to a point just west of Quebec City. TQM applied for new tolls to be effective January 1, 1989 and January 1, 1990, a change in its common equity ratio and an increase in its rate of return on equity ratio, and an increase in its rate of return on equity. Rate of return issues were addressed in an oral hearing and all other issues were addressed by written submission. This report presents the results of the hearing, including the background to the application, the revenue requirements, rate base, depreciation and amortization, the cost of capital, operating costs, and tariff matters. The Board reduced the requested revenue requirements and denied the request to increase the equity for both years. The monthly toll was thereby reduced also. A list of intervenors and appearances is included.

0320 Transport, Handling, and Storage

Refer also to citation(s) 6885, 6891, 6909, 6914, 6915, 6916, 6917, 6922, 6923, 6924, 6925, 7626, 9022

6928 (ESC–CE-02783, pp. 5) **Status report on deregulation: the view of the distributor.** MacNabb, I. (Canadian Gas Association and Canadian Gas Research Inst., Don Mills, ON (Canada)). Economics Society of Calgary, AB (Canada). 1988. (CONF-8811296–: 4. annual Canadian natural gas marketing conference, Calgary (Canada), 16 Nov 1988; CE–02783). In *Assessing the challenge ahead.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN.

This paper covers the evolving role of distributors in the new environment and the success of deregulation. However, one of the remaining barriers to deregulation is the uncertainty about security of supply for Canadian market subsectors through contractual arrangements. While the issue is being addressed in various ways in all provinces, it has yet to be fully resolved, particularly between Ontario and Alberta. Distributors are also concerned that some freely negotiated contracts and prices have been challenged in the past on the basis of customer classes or about the supply market. The final point of concern is the need for rate setting flexibility and a balance between a value of service approach and the traditional cost of service approach.

0340 Combustion

Refer also to citation(s) 6808, 7872

6929 (GWI–7610) **Minimisation of NO_x formation in natural gas combustion with strong air preheating in HTR reactors.** Flamme, M.; Kremer, H.; Beckervordersandforth, C.P. Gaswaerme-Institut e.V., Essen (Germany, F.R.); Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). 7 Mar 1988. 279p. (In German). Contract BMFT 03E-6291-A. Order Number DE90732394. Available from NTIS (US Sales Only), PC A13/MF A01.

The studies on industrial gas burners for high-temperature processes made in the framework of this research project show that the burners have a relatively high NO_x reduction potential. Due to the large variety of burner types in the industrial sector for the large number of the different processes, it is impossible to give general construction hints with regard to a reduction in NO_x. As far as the process is concerned, the burners have to fulfil very different requirements such as complete burn-out of the combustion products in a high-speed burner and high emission impulse or a long flame in the case of glass melting tanks or rotary kilns of the cement industry. In principle, it is possible to use the staged incineration, the exhaust-gas recirculation and, in the case of larger burners, the step-wise fuel supply as $N0_x$ reduction measures. In addition to these reduction techniques, the NO_x formation is very much influenced by the burner parameters such as the gas-air mixing principle, the emission impulse, and the shape of the burner firing block. (orig./EF).

04 OIL SHALES AND TAR SANDS

Refer also to citation(s) 6823, 6828

6930 (AOSTRA–CE-02657) **UNITAR/UNDP 4th International conference on heavy crude and tar sands, vol. 6.** Alberta Oil Sands Technology and Research Authority, Edmonton, AB (Canada). 1988. vp. (CONF-880807–: 4. UNITAR/UNDP international conference on heavy crude and tar sands, Edmonton (Canada), 7-12 Aug 1988; CE–02657). Available from Alberta Oil Sands Technology and Research Authority, 500 Highfield Pl., 10010-106 St., Edmonton, AB, CAN T5J 3L8. Prices: $150.00 CAN.

Major topics covered in this volume include worldwide resources in heavy oils and tar sands; petroleum geology; recovery processes; upgrading; waste management; equipment; and uses of natural bitumens. Separate abstracts have been prepared for 13 papers.

0402 Reserves, Geology, and Exploration

Refer also to citation(s) 6829, 6933

6931 (AOSTRA–CE-02657, pp. 43) **Use of biological markers in determining thermal maturity of biodegraded heavy oils and solid bitumens.** Palacas, J.G. (U.S. Geological Survey, Denver, CO (USA)); Anders, D.E.; King, J.D.; Lubeck, C.M. Alberta Oil Sands Technology and Research Authority, Edmonton, AB

(Canada). 1988. (CONF-880807--: 4. UNITAR/UNDP international conference on heavy crude and tar sands, Edmonton (Canada), 7-12 Aug 1988; CE--02657). In *UNITAR/UNDP 4th international conference on heavy crude and tar sands, vol. 6.* Available from Alberta Oil Sands Technology and Research Authority, 500 Highfield Pl., 10010-106 St., Edmonton, AB, CAN T5J 3L8. Prices: $150.00 CAN.

This paper reports the evaluation of the utility of two aromatic steroid hydrocarbon measurements, aromatization, and triaromatic enrichment, in assessing the maturity and source of biodegraded heavy oil-tar sand deposits in two different geological settings: the overthrust belt in western Greece and in the Uinta Basin in Utah. Two other biological markers, C29 sterane 20S/20S+20R and Tm/Ts are also used for verification purposes. Most samples investigated were tar sands, oil seeps, and solid bitumen collected from surface exposures although some samples were taken in shallow boreholes. Distribution of biological marker compounds was determined by computerized-mass spectrometry (GC-MS). The occurrence of triaromatic steroids, monoaromatic steroids, steranes, and terpanes were monitored. Results show that the use of either aromatization or triaromatic enrichment ratio alone can be misleading in determining relative maturation of immature or marginally mature oils. These measurements appear to be more reliable in assessing mature sequences. The effect of the original organic source material appears to be the primary factor affecting the reliability of the measurements, although migration, analytical error, biodegradation, and water washing effects could play a significant role. For meaningful maturity assessment of biodegraded as well as non biodegraded oils, multiple maturity parameters must be used. Based on evaluation of the combination of the four biological markers, the oils from western Greece were derived from moderately mature sources and the Trifos oil from deep, mature sources. The Uinta basin oils were derived from shallow, immature and at best marginally mature sequences. 24 refs., 13 figs., 4 tabs.

6932 (AOSTRA--CE-02657, pp. 25) **The McMurray Formation in the subsurface of syncrude oil sands lease 17, Athabasca oil sands. A physical sedimentological study in an area of exeptional drill core control.** Fox, A.J. (Dome Petroleum Ltd., Calgary, AB (Canada)); Pemberton, S.G. Alberta Oil Sands Technology and Research Authority, Edmonton, AB (Canada). 1988. (CONF-880807--: 4. UNITAR/UNDP international conference on heavy crude and tar sands, Edmonton (Canada), 7-12 Aug 1988; CE--02657). In *UNITAR/UNDP 4th international conference on heavy crude and tar sands, vol. 6.* Available from Alberta Oil Sands Technology and Research Authority, 500 Highfield Pl., 10010-106 St., Edmonton, AB, CAN T5J 3L8. Prices: $150.00 CAN.

In the Athabasca Oil Sands of northeastern Alberta, clean, well sorted sands with good porosity and permeability, have the highest bitumen saturation. Through the analysis of sedimentary structures and stratification sequences it was determined what physical processes and depositional environments were responsible for the sedimentary sequences that characterize the McMurray Formation. Four distinct lithostratigraphic subdivisions comprise the McMurray Formation in the present study area. The lower member accumulated in a high sinuosity fluvial environment, with deposition occurring in fluvial channels and adjacent overbank areas. The middle member developed in an estuarine environment with deposition occurring mainly in tidal channels and to a lesser extent on adjacent channel margins and intertidal flats. Filling an incision on the top of the middle member are sequences of the limy unit that were deposited mostly in tidal channels. Sharply truncating both the middle member and the limy unit are sequences of the upper member that were deposited in a nearshore to offshore environment. The bulk of the upper member was deposited in a series of linear nearshore bars and interbar troughs. These deposits are sharply overlain by sequences marking the onset of more offshore conditions. 20 figs., 32 refs.

6933 (CIM/S--CE-02846, pp. 11) **Paleozoic carbonates of western Saskatchewan: A potential heavy oil play.** Kent, D.M. (Univ. of Regina, Regina, SK (Canada)). Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278--: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE--02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

Two stratigraphic intervals in Western Saskatchewan, in widely separated areas, contain the largest proportion of the heavy oil shows. The Upper Devonian Birdbear Formation has numerous shows in the Kindersley area and the Mississippian Madison Formation of the southwest has been penetrated by 14 wells that have heavy oil occurrences in core or drillstem tests. Limited oil production has been obtained from both stratigraphic intervals. The Birdbear shows are in thin streaks of rhombic dolomite and in partially calcite-cemented vugs in a thinly bedded, dominantly microcrystalline dolomite. The Madison shows are found in dolomitized and recrystallized skeletal wackestones and crinoidal packstones and grainstones. The dolomitization has affected rocks within the upper 10-15 meters immediately beneath the sub-Mesozoic unconformity and appears to occur mainly on paleotopographic positive features. Mercury injection capillary pressure analyses permit the separation of the Madison rocks into two good reservoir and two poor or non-reservoir types and can be used to assist in the determination of the volume of oil-in-place in the Madison Formation. Three potentially good producing localities appear to exist in the Madison in the south Cypress Hills area. They have a combined estimated oil-in-place of between 30 x 10^6 and 40 x 10^6 m^3. 5 refs., 5 figs.

0403 Drilling, Fracturing, and Mining

Refer also to citation(s) 6839, 6840, 8190

6934 (CIM/S--CE-02846, pp. 9) **Winter reservoir: Horizontal well project.** Sharp, D.A. (CS Resources Ltd. (Canada)). Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278--: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE--02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

The Winter pool, a heavy oil reservoir located in the Lloydminster area of Saskatchewan, was selected as a suitable candidate for the introduction of a horizontal well production system. An initial two-phase program comprising five horizontal wells and four vertical monitoring wells has been undertaken by CS Resources and its partners to evaluate the applicability of horizontal wells to improve primary production. Reservoir performance will be assessed within the context of ultimately employing other enhanced recovery methods to compliment horizontal wells. 3 refs. 1 fig., 2 tabs.

0404 Oil Production, Recovery, and Refining

Refer also to citation(s) 6687, 6841, 7689, 7694, 8090, 8092, 8146

6935 (AOSTRA--CE-02657, pp. 11) **Oil shale processing with the AOSTRA [Alberta Oil Sands Technology and research Authority] Taciuk processor.** Turner, L.R. (Alberta Oil Sands Technolgy and Research Authority, Edmonton, AB (Canada)); Wright, B.C.; Taciuk, W. Alberta Oil Sands Technology and Research Authority, Edmonton, AB (Canada). 1988. (CONF-880807--: 4. UNITAR/UNDP international conference on heavy crude and tar sands, Edmonton (Canada), 7-12 Aug 1988; CE--02657). In *UNITAR/UNDP 4th international conference on heavy crude and tar sands, vol. 6.* Available from Alberta Oil Sands Technology and Research Authority, 500 Highfield Pl., 10010-106 St., Edmonton, AB, CAN T5J 3L8. Prices: $150.00 CAN.

The Taciuk Processor has been developed for the simultaneous extraction and primary upgrading of oil sands bitumen. Recently, attention has been given to other possible applications for the processor. One such application is the thermal retorting of oil shales for the recovery of liquid hydrocarbons. Tests were carried out on the performance of the processor in both batch and continuous flow pilot plant operations using oil shale feedstock obtained from the Kerosene Creek Member of the Stuart Oil Shale Deposit in Queensland, Australia. Results were as follows: the Taciuk Processor, as developed for oil sands processing, readily handles Stuart oil shales in stable, trouble-free operation. Operating results are reproducible; shale oil yield and oil quality are acceptable and may be improved

with further optimization of operating conditions and a purpose designed oil recovery system; combustion of carbon on spent shale is more than adequate to satify heat requirements without auxiliary firing. Design of the oil recovery system will require proper consideration of the fine solids carried over in the hydrocarbon vapor. Flue gas clean-up and spent shale disposal are accomplished with conventional procedures and equipment. 7 refs., 1 tab.

6936 (AOSTRA–CE-02657, pp. 39) **The heated annulus steam drive process for immobile tar sands.** Anderson, D.J. (Chevron Oil Field Research Co., La Habra, CA (USA)). Alberta Oil Sands Technology and Research Authority, Edmonton, AB (Canada). 1988. (CONF-880807–: 4. UNITAR/UNDP international conference on heavy crude and tar sands, Edmonton (Canada), 7-12 Aug 1988; CE–02657). In *UNITAR/UNDP 4th international conference on heavy crude and tar sands, vol. 6.* Available from Alberta Oil Sands Technology and Research Authority, 500 Highfield Pl., 10010-106 St., Edmonton, AB, CAN T5J 3L8. Prices: $150.00 CAN.

This paper describes the HASdrive (heat annulus steam drive) process, developed and sustained by creating a heated annulus around a horizontal non-perforated wellbore through which steam is circulated. Bitumen production is effected by means of a conventional steam drive where the vertical injector and producer are located at opposite ends of the heated annulus. Physical models representing a variety of oil sands field conditions were used to study the effect of the HASdrive process on bitumen recovery. Overall recoveries of greater than 60% are attainable. Premature steam breakthrough is not a problem and overall oil-steam ratios of at least 0.2 are attainable. Steam distillation occurs in the steam swept zone but is insufficient to affect significantly the gravity of the produced bitumen. Non-ionic surfactant flooding after steam breakthrough can recover a significant portion of the residual bitumen. 10 refs., 24 figs.

6937 (AOSTRA–CE-02657, pp. 17) **Application of basal water sands to enhance thermal recovery.** Kisman, K.E. (Alberta Oil Sands Technology and Research Authority, Calgary, AB (Canada)); Acteson, W.H. Alberta Oil Sands Technology and Research Authority, Edmonton, AB (Canada). 1988. (CONF-880807–: 4. UNITAR/UNDP international conference on heavy crude and tar sands, Edmonton (Canada), 7-12 Aug 1988; CE–02657). In *UNITAR/UNDP 4th international conference on heavy crude and tar sands, vol. 6.* Available from Alberta Oil Sands Technology and Research Authority, 500 Highfield Pl., 10010-106 St., Edmonton, AB, CAN T5J 3L8. Prices: $150.00 CAN.

In 1973-74, a successful single well cyclic steam simulation test was carried out on Peace River deposit oil sands. This was followed by large scale pilot tests for 1977 to 1985. The Computer Modelling Group's ISCOM thermal simulator was used to history match the 1973-74 single well cyclic stimulation test in order to study the principal mechanisms of thermal recovery of bitumen via basal water sands. The following mechanistic trends were identified. The reservoir initially has oil-wet characteristics with a favorable permeability versus water saturation relation. As a region in the reservoir is heated, its wettability changes to take on water-wet characteristics, with much reduced water relative permeability. The tar bank that surrounds the heated zone has reduced water permeability during production periods. These properties, combined, lead to good injection and production performance. 23 refs., 13 figs., 1 tab.

6938 (AOSTRA–CE-02657, pp. 19) **Reducing the sludge problem by co-processing sludge with oil sands ore.** Kruyer, J. (OLEOPHILIC SIEVE Development of Canada Ltd., Edmonton, AB (Canada)). Alberta Oil Sands Technology and Research Authority, Edmonton, AB (Canada). 1988. (CONF-880807–: 4. UNITAR/UNDP international conference on heavy crude and tar sands, Edmonton (Canada), 7-12 Aug 1988; CE–02657). In *UNITAR/UNDP 4th international conference on heavy crude and tar sands, vol. 6.* Available from Alberta Oil Sands Technology and Research Authority, 500 Highfield Pl., 10010-106 St., Edmonton, AB, CAN T5J 3L8. Prices: $150.00 CAN.

The Oleophilic Sieve represents new technology that has broad applications in oil sands development because it uses oleophilic adhesion forces, combined with buoyancy forces, to separate bitumen from slurries, sludges, and from other water based suspensions. These combined forces are much larger than the forces of buoyancy alone. Bitumen is very close in specific gravity to water at ambient temperatures, and aeration or elevated temperatures, or lighter hydrocarbon solvents, are required in other processes to enhance the buoyancy forces for separation. This is not required with the Oleophilic Sieve. The technology was pilot tested with mined oil sands, middlings, tailings, tailings pond sludge, and water based bitumen emulsions. In each case, high bitumen recoveries were achieved with low energy requirements. Fines content up to 25% in the suspension and separation temperatures from 50^{0}C to 5^{0}C have been used with good results. Historical trends in conventional oil supplies and sludge generation from existing processes are described. 31 refs., 18 figs., 2 tabs.

6939 (CIM/S–CE-02846, pp. 12) **The potential of the immiscible carbon dioxide flooding process for the recovery of heavy oil.** Dyer, S.B. (Univ. of Alberta, Edmonton, AB (Canada)); Farouq Ali, S.M. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

The imiscible carbon dioxide flooding process has considerable potential for the recovery of moderately viscous oils, which are unsuited for the application of thermal recovery techniques. Approximately 95% of Saskatchewan heavy oil formations are less than 10m thick, and often have an underlying water sand; under these conditions, thermal methods are inefficient and uneconomical. Laboratory research conducted in the 1950s identified several aspects of carbon dioxide flooding such as viscosity reduction, oil swelling, miscibility effects, and solution gas drive. Both laboratory and field studies have been conducted to determine the effectiveness of the carbon dioxide process for heavy oil recovery. The objectives of this paper are to give a resume of the dominant mechanisms in the immiscible carbon dioxide displacement process, and to analyze field data in order to develop the minimum criteria for process selection. 62 refs., 4 figs., 2 tabs.

6940 (CIM/S–CE-02846, pp. 21) **Investigation of the mechanisms involved in the steam-air injection process.** Ivory, J.; DeRocco, M.; Paradis, N. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

Mainly as a result of low-temperature oxidation (LTO), the utilization of air as an additive to steam results in an increase in the rate at which oil is recovered. This paper presents results which were obtained from an ongoing mechanistic investigation into the LTO process. High quality Athabasca oil sand, with an average bitumen content of 13.2 wt%, was used in all the experiments. Seventeen experiments were performed, the first 3 (2 steam-only and 1 steam-air) in test facility 1, and the remaining 14 (4 steam-only and 1 steam-air, 3 water-only and 6 water-air) in test facility 2. The experiments were designed to determine the effect of the steam-air or water-air process on the pressure drop and residual saturation in cores which had been previously depleted by a steam or water flood. The effect of air injection on properties (viscosity, asphaltene content, and acid number) of the residual bitumen was measured. Moreover, changes caused by LTO reactions to the produced aqueous phase (sulfate, acetate, total inorganic carbon, and ph) and to the coke content of the post-run solids were determined.

6941 (CIM/S–CE-02846, pp. 19) **Tracers in analysis of steamfloods.** Stone, T. (Alberta Research, AB (Canada)); Perkins, E.; Schmidt, T. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information

Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

Both inert and reactive tracers have been used to further the understanding of thermal recovery applied to heavy oils and bitumen. They can be used to gain an understanding of process conformance, recovery mechanisms or even reservoir heterogeneities. Tracers are commonly transported in the water phase, which is the continuous phase in a water-wet porous medium. Inert aqueous tracers will follow the primary flow paths of the liquid water while reactive aqueous tracers can dissolve/precipitate away from these regions. This paper discusses inert tracers and reactive geochemical tracers as they have been used both independently or together in the analysis of steamflood processes. The dead-end pore volume caused by a swept out oil bearing zone in large-scale oil recovery experiments was predicted with a numerical simulator. This added confidence to the history match, because the shape and amplitude of observed inert tracer concentrations depended on the time dependent flow geometry of the oil phase, which could not be measured otherwise. Possible influence of well design in large-scale experiments where inert tracer pulses were injected and produced was analysed and shown not to influence pulse dispersion under the experimental conditions employed. An idealised field scale simulation was used to demonstrate the potential advantages of monitoring production fluids for reactive (silica) and inert (Cl) tracers. Use of a reservoir simulator that calculates the transport of these tracers was suggested to allow increased ability to history match and predict field performance. 11 refs., 15 figs.

6942 (CIM/S–CE-02846, pp. 16) **Scaling criteria for in-situ combustion experiments.** Islam, M.R. (Nova Husky Research Corp., AB (Canada)); Farouq Ali, S.M. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

In situ combustion, and its modified forms, continue to be important oil recovery processes. The applicability of in situ combustion to a wide range of reservoirs, and the recent advances, show that this process has unique advantages (and disadvantages). Laboratory studies of in situ combustion are hampered by the lack of suitable scaling criteria for the design of experiments. Apart from that, the experiments are usually labour-intensive and costly. This paper provides guidelines for the design of such experiments, and also discusses the laboratory methods currently used. The general problem of in situ combustion in a three-dimensional system is formulated, with attention to reacton kinetics and non-equilibrium phenomena. Appropriate boundary conditions, both for field and laboratory, are stated. Next, the partial differential equations are used to derive a set of scaling criteria. A number of alternative schemes are considered in this regard. Suggestions are offered concerning the use of the various options available for experimental design. The scaling criteria derived are used to examine the validity of results derived from fire tube tests, which are widely used to obtain basic information on the combustion behaviour of crude oils. It is shown that, among the parameters measured in such experiments, only a few, such as fuel content, have validity. 20 refs., 5 tabs.

6943 (CIM/S–CE-02846, pp. 9) **Layered bed hydrocracking of heavy oil.** Soveran, D.W. (Saskatachewan Research Council, SK (Canada)). Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

The projection objective was to develop a two-layer fixed-bed catalyst system suitable for high-conversion hydrocracking of heavy oil feedstocks. Heavy oil feedstocks contain a large fraction of pitch material (components boiling above 525^0 C), which is difficult to convert to lower boiling fractions. Two heavy oil feedstocks were tested, Lloydminster atmospheric residue and Athabasca bitumen. A typical cobalt-molybdenum commercial hydrotreating catalyst was used in the downstream layer. A variety of stabilizing catalysts was prepared for the upstream layer. The purpose of the stabilizing catalyst was to stabilize the demetallized and thermally-cracked conversion products (rendering them less reactive through the addition of hydrogen), thus making them less likely to form coke on the hydrotreating catalyst. The deactivation characteristics of the Co-Mo catalyst were established with each feedstock by performing extended continuous experiments. The highest conversion conditions were established with an extended run using the stabilizing catalyst alone. Two-layer experiments were performed with both feedstocks. A series of runs was performed where the reactor temperature profile was manipulated to achieve near complete conversion in the stabilizing layer, therefore reducing coke formation in the downstream layer. The stabilizing catalyst proved ineffective in extending catalyst life. Coke formation hindered unit operation, preventing complete pitch conversion and causing rapid catalyst deactivation. 9 figs., 3 tabs.

6944 (CIM/S–CE-02846, pp. 9) **The Husky bi-provincial upgrader.** Chase, S. (Husky Oil Operations Ltd., AB (Canada)). Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

The Bi-Provincial Upgrader Complex is designed to produce 7310 m^3/d of synthetic crude and 1270 m^3/d of asphalt from 8590 m^3/d of a 65/35 volumetric blend of Lloydminister and Cold Lake heavy oils. The Complex will consist of the existing Lloydminister refinery and the Bi-Provincial Upgrader. The upgrader is a new facility that will be located in Saskatchewan, about 8 km from the existing Husky refinery. The refinery is a 3975 m^3/d unit whose primary function is to produce asphalt from heavy oil. After start-up of the upgrader, the refinery will continue to produce asphalt, naptha, which is recycled to the production fields for use as a diluent, and a combined gas oil stream. This gas oil stream will by hydrotreated in the upgrader. The process configuration and some of the more important considerations in the process design of the upgrader are reviewed in this paper. The upgrader comprises the following functions: crude plant; primary upgrading plant (H-Oil unit delayed coker, and gas recovery unit); secondary upgrading plant (gas-oil hydrotreater and naphtha jet hydrotreater); hydrogen plant (pressure swing adsorption); sulfur plant (amine systems, sour water stripper, Claus sulfur recovery unit, and tail gas unit); utilities and offsites. 2 figs., 4 tabs.

6945 (PCCIM–CE-02786-2.vols, pp. 15) **Physical and numerical modelling of hot water and steamdrive recovery processes in a bypass dominated oil sand reservoir.** Toma, P. (Alberta Research Council, AB (Canada)); Reitman, V.; Coates, R.M.; Prowse, D.; Goobie, G. Petroleum Society of CIM (Canada). 1989. (CONF-8905249–: 40. annual technical meeting of the Petroleum Society of the Canadian Institute of Mining and Metallurgy (CIM), Banff (Canada), 28-31 May 1989; CE–02786). In *Building on 40 years of achievement: Volumes 1 and 2.* Available from Petroleum Society of the CIM, c/o AMOCO Canada, Box 200, Calgary, AB, CAN T2P 0H8. Prices: $80.00 CAN.

A laboratory based research program initiated in 1979 to develop efficient methods for enhancement of hot fluid drive recovery processes in oil sand reservoirs, at the Alberta Research Council is discribed. Major observations related to the hot fluid drive process in oil sands made during this program are summarized. Viscous extra-heavy oil reservoirs, both final recovery and maximum obtainable oil/steam ratios are a strong function of pressure drop. A simplified model summarizing numerous laboratory and computer simulated recovery processes is presented. This model can be used to predict the effect of interwell pressure drop on the recovery process for simplified reservoir situations and to assess the effects of depth, interwell distance, and various additives on recovery processes. Laboratory and numerical simulation, hot water versus steamdrive process, scale effects and specific pressure drop, temperature and heat balance and oil/steam ratio are described in detail. Conclusions drawn from experimental and numerical analysis

are presented. Final recovery in a hot-water-assisted additive process compares satisfactorily with the steamdrive process. However, lower oil/steam ratios observed for hot water processes than those observed for steamdrive result in the hot water processes being less economical than steam. 24 refs., 17 figs., 3 tabs.

6946 (PCCIM–CE-02786-2.vols, pp. 17) **The production of conventional heavy oil reservoirs with bottom water using steam-assisted gravity drainage.** Sugianto, S. (Saskatchewan Oil and Gas Corp., SK (Canada)); Butler, R.M. Petroleum Society of CIM (Canada). 1989. (CONF-8905249–: 40. annual technical meeting of the Petroleum Society of the Canadian Institute of Mining and Metallurgy (CIM), Banff (Canada), 28-31 May 1989; CE–02786). In *Building on 40 years of achievement: Volumes 1 and 2.* Available from Petroleum Society of the CIM, c/o AMOCO Canada, Box 200, Calgary, AB, CAN T2P 0H8. Prices: $80.00 CAN.

This paper investigates a new, innovative thermal oil recovery process, that shows potential for the economic of production heavy oil from reservoirs where recovery is limited by water coning. The process used parallel horizontal wells placed near the bottom of the reservoir with horizontal steam injection wells located vertically above the producers near to the top of the reservoir. Experiments were performed using a scaled two-dimensional reservoir model containing an active aquifer system. The model was designed to provide dimensional similarity with specific Lloydminster type heavy oil field conditions. The study investigated the mechanism, the process, and the effects of steam injection pressure, bottom water thickness, the location of the production well; the laboratory results were extrapolated to the field conditions. It is shown that the process may produce heavy oils economically. The severity of steam coning was reduced because the high productivity index of a horizontal well, allows practical production at rates which are below the critical steam coning rates. Water production from the aquifer was greatly reduced by operating the production wells at pressures close to that of the aquifer. The cumulative oil recovery varied from 48% (bottom water case with 41% water in the model) to 87% (no bottom water with 0% water in the model) of original oil-in-place above the production well. The thickness of the bottom water zone and the well configurations employed had a significant effect on the cumulative oil recovery. 8 refs., 22 figs., 3 tabs.

0405 Properties and Composition

Refer also to citation(s) 6715, 6735, 8092

0406 Products and By-Products

Refer also to citation(s) 8185

6947 (AOSTRA–CE-02657, pp. 2) **Problems of complex use of natural bitumens.** Gribkov, V.V. Alberta Oil Sands Technology and Research Authority, Edmonton, AB (Canada). 1988. (CONF-880807–: 4. UNITAR/UNDP international conference on heavy crude and tar sands, Edmonton (Canada), 7-12 Aug 1988; CE–02657). In *UNITAR/UNDP 4th international conference on heavy crude and tar sands, vol. 6.* Available from Alberta Oil Sands Technology and Research Authority, 500 Highfield Pl., 10010-106 St., Edmonton, AB, CAN T5J 3L8. Prices: $150.00 CAN.

Heavy oils and natural bitumens are difficult and uneconomical to upgrade because processing catalysts are deactivated by substances such as asphaltenes, sulfur, nitrogen compounds, resins, and metals that occur at relatively high levels in these substances. These substances as well as the complex organics that occur in heavy oils and bitumen are potentially valuable byproducts of their refining. Traditional refining methods such as fluid coking, and flexicoking for heavy oil and upgrading for bitumens do not ensure the full use of the raw materials because some potential byproducts are difficult to recover and because recovery methods have not been fully investigated. Potential uses for these byproducts are discussed briefly. The evaluation of the economic potential of all heavy oil components is recommended as part of development planning.

0408 Economic, Industrial, and Business Aspects

Refer also to citation(s) 6863

0409 Waste Management

Refer also to citation(s) 6937

6948 (IT–CE-02787, pp. 29) **Treatment of oil sands and heavy oil production wastes using the AOSTRA [Alberta Oil Sands Technology and Research Authority] Taciuk Process.** Turner, L.R. (Alberta Oil Sands Technology and Research Authority, Edmonton, AB (Canada)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

The Alberta Oil Sands Technology and Research Authority Taciuk Process is a thermal retorting or pyrolysis process that has been developed for the simultaneous extraction and primary upgrading of bitumen from mined oil sands. The process is potentially capable of treating a wide variety of hydrocarbons bearing solid materials to separate and recover as discrete products a dry, oil-free solid residue, distillable liquid hydrocarbons, and process water. The process can also be used advantageously in the treatment of oily waste materials generated during the production of crude oils and in particular heavy crude oil and bitumen. This paper outlines the present pilot plant experience in the treatment of such oily waste. The paper describes extensive batch and continuous flow pilot plant tests on a variety of production waste sampmles. Analysis of the residential solids coupled with the results of leachate tests of the residual solids indicates that these solids would be suitable for disposal in a class 3 landfill. The performance of the pilot plant tests and the results of analysis of feed and products are described. Treatment costs are presented for a range of treatment plant capacities. 3 figs., 9 tabs.

0410 Environmental Aspects

6949 (IT–CE-02787, pp. 15) **Oil sand production facility spill prevention: Case history.** Holzman, L.R. (Esso Resources Canada Ltd., Cold Lake, AB (Canada)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Pipelines (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

This paper examines spill prevention techniques used at Esso Resources Canada Limited's Oil Sands project located near Cold Lake, Alberta. Details are provided on spill prevention for spill resulting from sand erosion, pipeline leaks, steamline warm-up procedures and creek crossings. Using the Cold Lake Production Project as a cast study, details are provided on spill prevention through facility design, operational procedures and preventive maintenance programs. Three cuases of spills are discussed: equipment facture caused by sand erosion, equipment damage due to hammer during steam line warmup, and pipline leaks. Operational methods and equipment features designed to overcome these problems is discussed.

0430 Transport, Handling, and Storage

Refer also to citation(s) 8164

05 NUCLEAR FUELS

Refer also to citation(s) 8995, 8996

6950 (EUR–8520) **Plutonium fuels and actinide programme: Annual status report, 1982: Multiannual programme of the Joint Research Centre, 1980–1983.** Commission of the European Communities, Luxembourg (Luxembourg). Directorate General Telecommunications, Information Industries and Innovation.

c 1983. 9p. Sponsored by Commission of the European Communities. Available from NTIS (US Sales Only), PC A02/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg; Price: ECU 3.40.

Research programs on plutonium fuels and actinides are briefly described. Topics include: operation limits of plutonium fuels, including swelling oxide fuel transients, and equations of state of nuclear materials; actinide cycle safety, which includes formation of actinides, safe handling of plutonium fuel, and head-end processing of carbide fuel; and, actinide research in crystal chemistry, solid state studies, and applied actinide research. 4 figs. (CBS)

0501 Reserves, Exploration, and Mining

6951 (DOE/EIA–0477(88)) **Domestic uranium mining and milling industry, 1988: Viability assessment.** USDOE Energy Information Administration, Washington, DC (USA). Office of Coal, Nuclear, Electric and Alternate Fuels. 11 Dec 1989. 98p. Sponsored by U.S. DOE Management & Administration. Order Number DE90004194. Available from NTIS, PC A05/MF A01 - GPO - OSTI; GPO Dep.

The current report provides the data and analyses, based on the information available through the end of the calendar year 1988, supporting the sixth annual assessment of the uranium industry's viability. It presents information on the four major attributes. Data on past and present industry behavior, as well as projections of the future status of the industry (assuming current market conditions), were used to examine the industry's ability to respond, over a 10-year period, to a variety of hypothetical supply disruptions. 21 figs., 23 tabs.

0504 Feed Processing

6952 (INIS-mf–12023, pp. 145-172) **Leaching of complex ores with radioactive impurities, e.g. monazite, followed by rare earth solvent extraction.** Ballhorn, R.; Brodt, P. Kernforschungsanlage Juelich GmbH (Germany, F.R.). Projektleitung Material- und Rohstofforschung; Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). 1987. (In German). Contract BMFT 03R072. (CONF-8711333–: Seminar on materials separation and enrichment, Goslar (Germany, F.R.), 23-24 Nov 1987). In *Materials separation and enrichment. Research and development sponsored by the Federal Minister for Research and Technology.* Order Number DE90732327. Available from NTIS (US Sales Only), PC A14/MF A01.

Pre-crushing plays a decisive role in the chemical development of monazite, the orthophosphate of the rare earth elements. Various mineralogical investigation methods - mineral-optical investigations, diffractometric surveys, thermoluminescence investigations - were applied in accordance with various grinding methods, with the aim of studying the possible effect of physically produced grid flows on the effectiveness of leaching. To obtain 95% of the rare earth elements, individual parameters such as grinding intensity, HNO_3 concentration, acid-concentrate ratio, temperature, duration of leaching and foreign ion admixture were varied, and the whole process was optimized. The recently developed method is compared with older methods with regard to profitability, the extraction of marketable uranium and thorium, etc., with a low accumulation of radioactive residues. (RB).

0505 Uranium Enrichment

6953 (GAO/RCED–89-170BR) **Uranium enrichment: Some impacts of proposed legislation on DOE's program.** General Accounting Office, Washington, DC (USA). Resources, Community and Economic Development Div. 1989. 43p. Available from US General Accounting Office, PO Box 6015, Gaithersburg, MD 20877.

GAO was asked to address several questions concerning a number of proposed uranium enrichment bills introduced during the 100th Congress. The bill would have restructured the Department of Energy's uranium enrichment program as a government corporation to allow it to compete more effectively in the domestic and international markets. Some of GAO's findings discussed are: uranium market experts believe and existing market models show that the proposed DOE purchase of a $750 million of uranium from domestic producers may not significantly increase production because of large producer-held inventories; excess uranium enrichment production capacity exists throughout the world; therefore, foreign producers are expected to compete heavily in the United States throughout the 1990s as utilities' contracts with DOE expire; and according to a 1988 agreement between DOE's Offices of Nuclear Energy and Defense Programs, enrichment decommissioning costs, estimated to total $3.6 billion for planning purposes, will be shared by the commercial enrichment program and the government.

6954 (JAERI-M–89-098) **Simulation analysis of molecular laser isotope separation process for safeguards design.** Okamoto, Tsuyoshi (Tokyo Univ. (Japan)); Nishimura, Hideo. Japan Atomic Energy Research Inst., Tokyo (Japan). Aug 1989. 48p. (In Japanese). Order Number DE90733139. Available from NTIS (US Sales Only), PC A03/MF A01.

In this report, firstly an approach to a satisfactory safeguards concept is studied and proposed, among other things, as such that a process model should be developed only on a basis of published theories and data and that the safeguards should be designed using this process model. Secondly, as the first step of this approach, the photon-molecular reaction dynamics for a uranium-235-selective excitation process which is one of the infrared multi-photon dissociation processes for uranium enrichment was computer-simulated using a mathematical model as follows: through the investigation of a selective excitation probability in each energy level and of the transition probability to quasi-continuum levels from the top discrete level, a sensitivity analysis was carried out on the important parameters for process operations such as the optimum relative intensities between the laser for selective excitation and the laser for dissociation, the laser pulse widths to be required, and the asynchronous multi-laser irradiation. As a result, the conditions to be satisfied by such operational parameters in the design of photon-excited selective process were made clear. Although the dissociation process in the quasi-continuum and in the true continuum levels must be investigated in order to have a complete picture of the uranium-235 separation process, the optimization of the photon-excited selective process which was analyzed in this report is the most important theme for the molecular laser uranium enrichment and the detailed analysis of the characteristics of such excitation process not only gives fundamental data for the design of enrichment process but also is necessary for analyzing the diversion possibilities of producing higher enrichment than declared for safeguards design. (author).

0507 Fuels Production and Properties

Refer also to citation(s) 7568, 7569, 7573, 8554

6955 (WSRC-RP–89-480) **An electronic procedure system for WSRC fuel material facility.** Derr, S.M.; Sloan, C.W. Westinghouse Savannah River Co., Aiken, SC (USA). 1989. 21p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. (CONF-891192–21: Annual Westinghouse computer symposium, Pittsburgh, PA (USA), 6-7 Nov 1989). Order Number DE90003897. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The production of naval fuel, like many production processes within the Westinghouse complex, depends very heavily on strict procedure compliance. Thus operators need to have quick access to procedures and they need to have some assurance that they are using the most current revision. This is often both difficult and time consuming on a production floor. In order to resolve some of these problems two members of the Naval Fuel Product Team are currently developing an electronic procedure system. It is the intent of the system to have workstations on the production floor. These workstations will be networked to a centralized computer used exclusively as a file server for holding the current revision of each procedure. By simply clicking a mouse on the appropriate icon, a user will be able to access any procedure required in his portion of the process. In this user friendly environment the operator can either read the procedure on the workstation screen or print a copy of the procedure at a nearby printer. Since it is often the case that a graphic is used in one procedure is also used in other procedures, we plan to store individual graphics separately from a given procedure. In this way when a graphic changes, only one correction

needs to be made in order for that graphic to be automatically updated in every procedure in which it is used. In the future we plan to expand the system so that the operator will be able to enter procedure data into the procedure. We have plans for this to be a platform for both the Distributive Control and Nuclear Accountability Systems. Farther down the road we envision operating in a real-time environment were the workstation would be able to read data directly from equipment in the process. 14 figs.

6956 (WSRC-RP–89-489) **Properties of aluminum-uranium alloys.** Peacock, H.B.; Frontroth, R.L. Westinghouse Savannah River Co., Aiken, SC (USA). Aug 1989. 71p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. Order Number DE90003889. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

Enriched aluminum-uranium alloys have been used for nuclear reactor fuel elements at the Savannah River Site (SRS) for over 30 years. The alloy also has been used for fuel in research and test reactors in the international community. Over 200,000 elements have been successfully irradiated at SRS without incident. No known accidents related to the fuel have occurred during irradiation with the exception of a few cladding penetrations due to localized corrosion. Aluminum-uranium fuel elements are proposed for the New Production Reactor (NPR). To carry out design and study irradiation behavior, physical, mechanical and chemical properties were obtained from the literature and assembled into a manual so a consistent set of data are available. 56 refs., 26 figs., 10 tabs.

0508 Spent Fuels Reprocessing

6957 (CONF-890304–37) **Head-end reprocessing equipment remote maintenance demonstration.** Evans, J.H.; Metz, C.F. III;. Oak Ridge National Lab., TN (USA). [1989]. 10p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. From 3. ANS topical meeting on robotics and remote systems; Charleston, SC (USA); 13-16 Mar 1989. Order Number DE90003055. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Prototype equipment for reprocessing breeder reactor nuclear fuel was installed in the Remote Operation and Maintenance Demonstration (ROMD) area of the Consolidated Fuel Reprocessing Program (CFRP) facility at the Oak Ridge National Laboratory (ORNL) in order to evaluate the design of this equipment in a cold mock-up of a remotely maintained hot cell. This equipment included the Remote Disassembly System (RDS) and the Remote Shear System (RSS). These systems were disassembled and reassembled remotely by using the extensive remote handling systems that are installed in this simulated hot-cell environment. 5 refs., 5 figs.

0509 Transport, Handling, and Storage

Refer also to citation(s) 7036, 7042

6958 (EUR–11809) **Contaminated smoke: A simulation of the heavy metal containing aerosols from fires in plutonium glove boxes.** Buijs, K. (Commission of the European Communities, Karlsruhe (Germany, F.R.). European Inst. for Transuranium Elements); Chavane de Dalmassy, B. Commission of the European Communities, Luxembourg (Luxembourg). Directorate General Telecommunications, Information Industries and Innovation; Commission of the European Communities, Karlsruhe (Germany, F.R.). European Inst. for Transuranium Elements. c 1988. 54p. Sponsored by Commission of the European Communities. Available from NTIS (US Sales Only), PC A04/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg; Price: ECU 5.

With the aim of studying the dispersion of plutonium bearing aerosols during glove box fires on a full-size laboratory scale, a special fire-chamber simulating a plutonium handling facility and equipped with the necessary analytical instrumentation was developed. For comparative fire studies, a 0.6 MW fire source was standardized, with a reproducibility better than 10%. PMMA (a major glove box construction material) was used as combustible material for this standard fire, to which, if required, samples of other construction materials can be added. Using cerium-europium oxide as a substitute for plutonium oxide for surface contamination of the material, the percentages of the airborne contamination carried away with the combustion gases and remaining inside the fire chamber after a standard fire, are measured. During the fire, between 60 and 75% of the original contaminant lanthanide oxide becomes airborne, 1–2% are carried away with the combustion gases into the ventilation outlet. 13 refs., 17 figs., 5 tabs.

0510 Economic, Industrial, and Business Aspects

Refer also to citation(s) 6950, 6952

0520 Waste Management

Refer also to citation(s) 7038, 8000, 8089, 8152, 8440

6959 (AERE-R–12774) **The equilibrium leach testing of ferric/aluminium hydroxide flocs.** Biddle, P.; Greenfield, B.F.; Greenham, P.S.; Rees, J.H.;. UKAEA Harwell Lab. (UK). Chemistry Div. Sep 1987. 25p. (ILWRP–86/P9). Available from Available from H.M. Stationery Office, London, price Pound 8.00.

Equilibrium leach tests have been carried out on ferric/aluminium hydroxide flocs using cement and resin matrices, and cement and clay backfills in both air and nitrogen atmospheres. The equilibrium concentrations of a number of actinides and fission products were measured in leachates obtained over periods of up to a year. The lowest equilibrium actinide concentrations were found in leachates from systems with a cement backfill. Cement matrix-cement backfill was the most promising combination for limiting concentrations of long-lived radionuclides, resin-clay the least. Comparisons of leachate concentrations with limiting drinking water concentrations are made and the high degree of protection afforded by candidate near field components shown. (author).

6960 (CONF-900121–3) **Factors that may influence responses of the US transportation sector to policies for reducing greenhouse gas emissions.** Hillsman, E.L.; Southworth, F. Oak Ridge National Lab., TN (USA). 1990. 30p. Sponsored by U.S. DOE Environment Health & Safety. DOE Contract AC05-84OR21400. From Transportation Research Board meeting; Washington, DC (USA); Jan 1990. Order Number DE90000704. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Transportation vehicle operations in the US contribute 32% of the nation's emissions of carbon dioxide, and 7% of the world's emissions from energy use. Technical options exist to reduce emissions rates, but policies to reduce emissions must recognize the fragmentation of responsibility for key transportation activities among diverse groups of decision makers, and the need to coordinate their decisionmaking. Policies to increase vehicle fuel efficiency affect decisions by vehicle suppliers, transportation service suppliers, and those who demand transportation services. Policies to shift to alternative transportation fuels affect decisions by these decision makers, by fuel suppliers, and possibly by infrastructure developers as well. Long-term increases projected in the demand for transportation services will offset emission reductions from these policies unless service can be delivered by modes with lower emissions, or unless demand growth can be managed as is now occurring in other sectors of the economy. Additional research is needed to determine the most effective demand management strategies. 28 refs., 1 fig., 1 tab.

6961 (DOE/ID/12584–49) **Geophysical surveys at INEL/RWMC Cold Pit, Acid Pit, and Pit 9.** Hasbrouck, J.C. UNC Geotech, Grand Junction, CO (USA). Nov 1989. 238p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC07-86ID12584. (UNC/GJ–103). Order Number DE90003916. Available from NTIS, PC A11/MF A01 - OSTI.

UNC Geotech, prime Contractor at the US Department of Energy Grand Junction Projects Office (DOE/GJPO), conducted geophysical surveys of the Cold Pit, Acid Pit, and Pit 9 at the Radioactive Waste Management Complex (RWMC) of the Idaho National Engineering Laboratory (INEL) during a 3-week period beginning 30 January 1989. All geophysical field data were acquired and processed in accordance with established quality-assurance procedures, and interpreted by experienced geophysicists. This report describes the

surveys that were conducted and the results of the interpretation of those surveys. 10 refs., 2 figs., 2 tabs.

6962 (DOE-RW–89.016) **The effect of organics on the sorption of cobalt by glacial sand in laboratory experiments.** Haigh, G. (British Geological Survey, Keyworth (UK). Fluid Processes Research Group); Williams, G.M.; Hooker, P.J.; Ross, C.A.M.; Allen, M.R.; Warwick, P.;. Department of the Environment, London (UK). Feb 1989. 20p. Contract PECD-7/9/367. Order Number DE90612695. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The effect of acetate, EDTA and natural organic compounds in groundwater at Drigg test site, on the sorption of cobalt by glacial sand has been studied in a series of batch experiments. Removing 50% of the organic material from the groundwater with DEAE cellulose increased the distribution ratio (R_d) of cobalt by a factor of about two. The addition of both EDTA and acetate to the sand/water system led to the removal of Ca, Mg, Sr and Ba from solution. Both organic compounds had the effect of reducing the pH and bicarbonated concentrations. EDTA also removed iron from the solution. EDTA reduced the R_d for Co by up to 2 orders of magnitude. At EDTA concentrations greater than 5mg/1, there was no further reduction in sorption. EDTA was not itself sorbed, but formed a mobile complex with Co. Within the same period of equilibrium, the R_d values were lower when EDTA was allowed to equilibrate with the sand before adding cobalt. The desorption of cobalt from the minerals surface may be a rate limiting step such that equilibrium was not achieved within the 14 day period of these experiments. Acetate had no effect of cobalt sorption. (author).

6963 (DOE-RW–89.031) **The management of carbon-14 and iodine-129 wastes - a site specific survey of current and future arisings, possible management options and potential impact with respect to the United Kingdom.** Briggs, A. (UKAEA Harwell Lab. (UK). Materials Development Div.); Hart, D.;. Department of the Environment, London (UK). Jun 1988. 84p. Contract PECD-7/9/358. (AERE-R–12575). Order Number DE90612684. Available from NTIS (US Sales Only), PC A05/MF A01 - OSTI; INIS.

Part 1 - A site-specific survey, by the Harwell Laboratory, of current and future gaseous, liquid and solid arisings of ^{14}C and ^{129}I at UK nuclear installations, is presented in the form of tables and maps. In the tables the arisings are characterised in terms of quantity, activity and accompanying radionuclides. Management options discussed are: dispersal in the environment; capture and retention of arisings from power stations, reprocessing plants, and industrial sites producing pharmaceuticals and research materials; direct disposal of unprocessed spent fuel elements in an underground repository. Comparative costings of the various options are given. Part 2 - The information in part 1 is used by the National Radiological Protection Board as the basis for an examination of the effects that various management options would have on the radiological impact of ^{14}C and ^{129}I on the public. Comparison is made between different types of discharge, and disposal as a solid waste to various kinds of repository, in terms of their health detriment costs. Emphasis is placed on illustrating the use of a decision analysis methodology for assessment of the different waste management strategies. (author).

6964 (DOE-RW–89.032) **The influence of organic materials on the near field of an intermediate level waste radioactive waste repository.** Wilkins, J.D. (UKAEA Harwell Lab. (UK). Chemistry Div.);. Department of the Environment, London (UK). Feb 1988. 20p. (AERE-R–12719). Order Number DE90612696. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The influence of organic materials, which are present in some intermediate level wastes, on the chemistry of the near field of a radioactive waste repository is discussed. Particular attention is given to the possible formation of water soluble complexing agents formed as a result of the radiation field and chemical conditions. The present state of the research is reviewed. (author).

6965 (DOE-RW–89.039) **A review of modelling the interaction between natural organic matter and metal cations.** Falck, W.E. (British Geological Survey, Keyworth (UK). Fluid Processes Research Group);. Department of the Environment, London (UK). Jan 1989. 77p. Contract PECD-7/9/367. Order Number DE90612697. Available from NTIS (US Sales Only), PC A05/MF A01 - OSTI; INIS.

This report reviews techniques available to model the interaction between natural organic matter (mainly fulvic and humic acids) and metal cations and protons. A comprehensive overview over the properties of natural organic matter is given and experimental techniques are presented briefly. Two major concepts of modelling have been identified: discrete ligand models and continuous distribution model. Different modelling approaches like Discrete Ligand Models (s.s.), Random-Structure Model, Affinity Spectra, Statistical Distribution Models, Continuous Stability Function Models and surface sorption models and their advantages/disadvantages are discussed. (author).

6966 (DOE-RW–89.050) **Objectives and scope of the joint funded BNFL/DOE product evaluation development programme.** Fairhall, G.A. (British Nuclear Fuels Ltd., Sellafield (UK));. Department of the Environment, London (UK). Mar 1989. 20p. (ILWRP–89-P02). Order Number DE90612698. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

In 1983 British Nuclear Fuels plc (BNFL) and the Department of the Environment (DoE) initiated a joint funded development programme covering the product evaluation of Intermediate Level Wastes (ILW). The programme has been managed by the Research and Development Department (R and DD) of BNFL, Sellafield under the control of the Product Evaluation Task Force (PETF). The objectives of the PETF programme are: (i) to define the characteristics of individual ILW streams arising at Sellafield and assess their suitability for direct encapsulation; (ii) to evaluate different matrices for each ILW and select the preferred options for further study; (iii) to produce a database of information for each ILW encapsulated in its preferred matrix, that satisfies the requirements of the waste management stages from the initial waste processing to disposal. This paper describes the scope of the PETF programme. It defines the anticipated timescale for completing each of the development phases and identifies the reports to be produced. (author).

6967 (DOE-RW–89.054) **Immobilisation of ion exchange resins in cement: final report.** Howard, C.G. (UKAEA Atomic Energy Establishment, Winfrith (UK)); Jolliffe, C.B.; Lee, D.J.;. Department of the Environment, London (UK). Mar 1989. 66p. Contract PECD-7/9/356. (AEEW-R–2468). Order Number DE90612687. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

The removal of activity from spent decontaminating solutions eg LOMI can be achieved using organic ion exchange resins. These resins can be successfully immobilised in cement based matrices. The optimum cement system contained 10% Ordinary Portland Cement 84% gg Blast Furnace Slag, 6% Microsilica with a water cement ratio of 0.5 and a dry resin loading of 36% with respect to total weight. This information was successfully scaled up to 200 litres giving a product with acceptable compressive strength, dimensional stability and elastic modulus. Storage of samples under water appears to have no detrimental effects on the product's properties. (author).

6968 (DOE-RW–89.056) **Microstructure and microanalysis of some ancient building materials.** Majumdar, A.J. (Building Research Establishment, Watford (UK)); Rayment, D.L.; Pettifer, K.;. Department of the Environment, London (UK). Dec 1988. 35p. (BRE-CR–32/87). Order Number DE90612699. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

In order to assess the very long term of durability of modern Portland cements for encapsulating certain types of radioactive waste, the microstructure and microanalysis of concretes of various ages made from such cements are compared with those from similar materials of ancient origins with ages upto 2500 years used in early Greek, Roman and British Construction. Most of the historical 'concretes' examined were heavily carbonated and at best showed only traces of the calcium silicate hydrate (C-S-H) phase, the heart of modern Portland Cement concretes. The notable exception was the 1700 years old concrete from Hadrian's Wall - the mortar in this was rich in C-S-H. The modern concrete samples, from 10 to 140 years old, showed little carbonation and their compositions of the C-S-H phase were very similar to those found from Hadrian's Wall. From all the evidence examined, it is concluded that the C-S-H

phase is capable of surviving intact for several thousands of years in the absence of external chemical attack. (author).

6969 (DOE-RW–89.059(v.1)) **Removal of organics from radioactive waste. V. 1. Main report.** Williams, J. (Cremer and Warner, London (UK)); Kitchin, J.; Burton, W.H. and others. Department of the Environment, London (UK). May 1989. 117p. Order Number DE90610327. Available from NTIS (US Sales Only), PC A06/MF A01 - OSTI; INIS.

This report has been prepared to review the methods available to remove organics from nuclear waste. The limitations of the methods and their applicability to the type of waste streams likely to arise in the future is also considered. Although wide experience exists on the application of incineration technology to nuclear waste there is little operational experience that relates to other techniques that have been identified as appropriate for the treatment of nuclear waste streams with the exception of acid digestion which has a moderate amount of operating experience. All the techniques discussed in this report, namely; incineration; acid digestion; wet oxidation; alkaline hydrolysis; microbiological; molten salt; and molten glass; show some potential for dealing with various waste streams. However, the stage of research in each is insufficient to allow any firm conclusions to be drawn on their overall suitability to treating waste arisings, operability, economic cost or environmental costs. Without more research data it is also difficult to establish the overall volume reductions that may be possible. (author).

6970 (DOE-RW–89.059(v.2)) **Removal of organics from radioactive waste. V. 2. Literature review.** Williams, J. (Cremer and Warner, London (UK)); Kitchin, J.; Burton, W.H. and others. Department of the Environment, London (UK). May 1989. 165p. Order Number DE90610328. Available from NTIS (US Sales Only), PC A08/MF A01 - OSTI; INIS.

This report reviews the available literature concerning the removal of organic substances from radioactive waste streams. A substantial portion of low level wastes generated in the various parts of the nuclear fuel cycle, nuclear laboratories and other places where radionuclides are used for research, industrial medical and defense related activities is organic (paper, wood, plastics, rubber etc.) and combustible. These combustible wastes can be processed by incineration. Incineration converts combustible wastes into radioactive ashes and residues that are non-flammable, chemically inert and more homogenous than the initial waste. (author).

6971 (ENEA-RT-VEL–89-2) **A study on the radionuclide migration by means of the code LISA: General description and user manual.** Frenquellucci, F. (ENEA, Bologna (Italy)); Deserti, M. ENEA, Rome (Italy). 1989. 66p. (In Italian). Order Number DE90610840. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

LISA code (Long Term Isolation Safety Assessment) has been developed by J.R.C. EUROATOM Ispra (Radiochemistry Division) and it's utilized in order to study migration of radionuclides through porous media. Aim of the present work is to analyze LISA's input and output files. A brief description of the code is also performed. As LISA is a research and in development code, its structure is rather complex and an exhaustive description of input/output files is helpful for the user. Version 3 of LISA code, loaded on ENEA's IBM 3090, is avaylable by ENEA-VEL Bologna.

6972 (GSF–1/89) **Development of a fully automatic d.c. geoelectric system for barrier construction in salt rock strata.** Yaramanci, U.; Flach, D. Gesellschaft fuer Strahlen- und Umweltforschung m.b.H. Muenchen, Braunschweig (Germany, F.R.). Inst. fuer Tieflagerung. Jan 1989. 101p. (In German). Contract BMFT KWA 5603 6. Order Number DE90732391. Available from NTIS (US Sales Only), PC A06/MF A01.

The sealing of roadways by dams is an important measure for securing final storage sites to protect the environment. A pilot dam is set up in the Asse salt mine to investigate the technical feasibility and its effectiveness. The d.c. geoelectrics is particularly well suited as investigation and monitoring method as moisture naturally occurring in rock can be detected, and the migration of the caustic solution injected under high pressure for test purposes can be tracked. For accomplishing the measurement task which consists in carrying out a large number of measurements with different spatial electrode arrangements, a measuring system was developed mainly consisting of the actual geoelectric measuring device, a socalled multiplexer box and a control computer with software. By means of this system, electrodes from the electrode net installed in boreholes along the dam section can be switched, the measurements can be carried out, and the final values can be calculated and logged automatically. The system described in detail has already been installed in the driven roadway of the dam test field and put into operation. The installed electrode network consists of 189 electrodes in 21 boreholes or of 9 measuring horizons running transversely to the future dam roadway axis. (orig./HP).

6973 (GSF–25/88) **Sorption and desorption characteristics of selected radionuclides (14-C, 75-Se, 85-Sr, 95m-Tc/99-Tc, 131-I, 134-Cs and 210-Pb) in sediment rock samples of the Asse bedrock.** Wolfrum, C. (Gesellschaft fuer Strahlen- und Umweltforschung mbH Muenchen, Neuherberg (Germany, F.R.). Inst. fuer Hydrologie); Klotz, D.; Bode, W. Gesellschaft fuer Strahlen- und Umweltforschung m.b.H. Muenchen, Neuherberg (Germany, F.R.). 1989. 240p. (In German). Contract BMFT KWA 8502. Order Number DE90732324. Available from NTIS (US Sales Only), PC A11/MF A01.

Sorption tests were performed on the basis of 47 rock samples from Asse with C-14, Se-75, Tc-95m, Tc-99, I-131, Pb-210, Sr-85 and Cs-134 under aerobic and anaerobic testing conditions. Static sorption and desorption data were determined with the help of the batch technique, dynamic migration parameters in diffusion and column experiments. The distribution coefficients determined in various states of equilibrium in batch tests using sediment samples of <2 mm grain size increase in the sequence Se<Tc<C/I<Sr<Pb<Cs. The diffusion coefficients calculated in accordance with two different evaluation methods show values between 10^{-4} and 10^{-8} cm^2/s, depending on the radionuclide and sediment used. The dynamic distribution coefficients determined in continuous-flow tests under aerobic conditions with the help of 2-6 mm grain size sediment samples increase in the sequence Se/Tc<C/I<Sr<Cs. The dynamic distribution coefficients agree, in a first evaluation, with the sorption distribution coefficients determined in batch tests with sediments of the same grain size. (orig./HP).

6974 (INIS-mf–12027) **Investigation of the mobilization and sorption characteristics of selected radionuclides at natural and technical barriers under MAW final storage conditions. Final report.** Freie Univ. Berlin (Germany, F.R.). Inst. fuer Anorganische und Analytische Chemie; Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). 1988. 185p. (In German). Contract BMFT 02U5715. Order Number DE90732323. Available from NTIS (US Sales Only), PC A09/MF A01.

The final report summarizes the results of various research areas concerned with possible disposal-site accidents involving the destruction of containers containing radioactive waste by salt brine. The physico-chemical data obtained are intended to serve model calculations for probable risks. Prior attention is directed to the behaviour of ^{237}Np, ^{129}I, ^{135}Cs and ^{79}Se as long-lived nuclides, examined with ^{233}U, ^{131}I, ^{137}Cs and ^{75}Se as tracer nuclides. An initial research concern is with the characterisation of proximity zones during MAW emplacement in chambers and holes (pH, Eh, concentrations, carbonate concentrations, carrier colloids) in appropriate solution systems. The second research concern consists in the examination of the solubility and sorption behaviour of the elements involved, in the form of their compounds in the relevant systems. The third concern is with the sorption of the above mentioned elements in corrosion products of cement and of the materials of the tanks, as well as in salt grit and waste material. (RB).

6975 (INIS-mf–12028) **Hydrogeological, geohydraulic and geothermal studies on projected sites for final storage of nuclear waste. Sub-project 3. Geothermal studies. Final report.** Bundesanstalt fuer Geowissenschaften und Rohstoffe, Hannover (Germany, F.R.); Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). Sep 1988. 22p. (In German). Contract BMFT KWA 5309 0;BMFT KWA 8505 0;BMFT KWA 8504 9/2. Order Number DE90732322. Available from NTIS (US Sales Only), PC A03/MF A01.

The explanatory temperature field program for the surface rocks of the Gorleben salt dome was concluded. Statements about

groundwater flows could be deduced from the measuring results, especially in connection with the hydrogeological and geohydraulic research studies. The measuring results from the area of the freezing shafts provided contributions for the monitoring of the development of freezing bodies and for the explanation of the causes of the instability of freezing bodies which occurred during the sinking of shaft 1 and led to an interruption of the sinking work. The temperature data from the surface rocks are summarized in a documentary report. All measuring data are available in a database with EDP access. Temperature measurements in the borehole Konrad 101 contributed to the localization of water supplies and discharges in the hole and thus to a limitation of the areas with increased permeability within the hydraulic test sections. In thermophysical laboratory investigations, material constants for model calculations of the Federal Agency for Geosciences and Raw Material and the Physico-Technical Federal Agency (PTB) were determined for the locations Gorleben and Konrad. (orig./HP).

6976 (LA–11691-MS) **Characterization of reactive tracers for C-wells field experiments 1: Electrostatic sorption mechanism, lithium.** Fuentes, H.R.; Polzer, W.L.; Essington, E.H.; Newman, B.D. Los Alamos National Lab., NM (USA). Nov 1989. 121p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. Order Number DE90003988. Available from NTIS, PC A07/MF A01; OSTI; INIS; GPO Dep.

Lithium (Li^+) was introduced as lithium bromide (LiBr), as a retarded tracer for experiments in the C-wells complex at Yucca Mountain, Nevada Test Site, Nevada. The objective was to evaluate the potential of lithium to sorb predominately by physical forces. lithium was selected as a candidate tracer on the basis of high solubility, good chemical and biological stability, and relatively low sorptivity; lack of bioaccumulation and exclusion as a priority pollutant in pertinent federal environmental regulations; good analytical detectability and low natural background concentrations; and a low cost Laboratory experiments were performed with suspensions of Prow Pass cuttings from drill hole UE-25p#1 at depths between 549 and 594 m in J-13 water at a pH of approximately 8 and in the temperature range of 25°C to 45°C. Batch equilibrium and kinetics experiments were performed; estimated thermodynamic constants, relative behavior between adsorption and desorption, and potentiometric studies provided information to infer the physical nature of lithium sorption.

6977 (LA–11694-MS) **Status of image analysis methods to delineate stratigraphic position in the Topopah Spring Member of the Paintbrush Tuff, Yucca Mountain, Nye County, Nevada.** Campbell, K. (Los Alamos National Lab., NM (USA)); Broxton, D.E.; Spaw, J. Los Alamos National Lab., NM (USA). Oct 1989. 35p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. Order Number DE90004424. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The Topopah Spring Member of the Paintbrush Tuff is an ash-flow cooling unit that is the candidate host rock for a potential high-level nuclear waste repository at Yucca Mountain, Nevada. The repository workings will be mostly confined to the member's rhyolitic portion, which is chemically homogenous but texturally variable. This report describes the status of work to develop a useful internal stratigraphy for the rhyolitic portion of the member; our approach is to use an image analysis technique to map textural variations within the member as a function of stratigraphic height. Fifteen petrographic thin sections of Topopah Spring rhyolitic tuff were studied in each of two drill holes (USW GU-3 and USW G-4). Digital color images were collected in transmitted light for two scenes 1 cm on a side for each thin section. Objects within a scene were classified by color, and measurements of area, elongation, and roughness were determined for each object. Summary statistics were compiled for all measurements for each color component within a scene, and each variable was statistically examined for correlations with stratigraphic position. Our initial studies using image analysis have not yet produced a useful method for determining stratigraphic position within the Topopah Spring Member. Simplifications made in this preliminary application of image analysis may be largely responsible for these negative results. The technique deserves further investigation, and more detailed analysis of existing data is recommended. 9 refs., 11 figs., 4 tabs.

6978 (LA-UR–89-3733) **Sorption of americium in tuff and pure minerals using synthetic and natural groundwaters.** Triay, I.R.; Meijer, A.; Cisneros, M.R.; Miller, G.G.; Mitchell, A.J.; Ott, M.A.; Hobart, D.E.; Palmer, P.D.; Perrin, R.E.; Aguilar, R.D. Los Alamos National Lab., NM (USA). [1989]. 13p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. (CONF-891120–5: Migration '89: 2nd international conference on chemistry and migration behavior of actinides and fission products in the geosphere, Monterey, CA (USA), 6-10 Nov 1989). Order Number DE90003191. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The distribution of Am between selected solid and liquid phases has been studied using initial ^{241}Am solutions with a molarity smaller than 1×10^{-11}. The synthetic and natural groundwaters used have pH values in the 7–8 range and a total alkalinity of approximately 1 mN which is mainly due to bicarbonate. Mass spectrometric isotope dilution was utilized to determine the amount of Am in the solution phase initially and after equilibrium was attained. Using this sensitive technique, 7×10^8 atoms of ^{241}Am were accurately measured. Our results indicate that the percent of Am lost to the walls of the container in the absence of geologic material varies from 35 to 84. The Am sorption coefficient determined is on the order of 10^3 ml/g for clinoptilolite, 10^4 ml/g for tuff consisting mainly of alkali feldspar and cristobalite, and 10^5 ml/g for romanechite. 12 refs.

6979 (NIRS-R–16, pp. 136-144) **Studies on treatment of alpha-radioactive wastes.** Koizumi, Akira (National Inst. of Radiological Sciences, Chiba (Japan)); Yamada, Yuji; Miyamoto, Katsuhiro. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

Penetrations through several kinds of air filters were measured using dioctyl phthalate (DOP) particles, ambient particles and polystyrene latex particles. The filters tested were a Whatman GF/A filter, a HEPA filter media, a ULPA filter media, and a medium-efficiency filter media. The particle concentration was measured by an automated diffusion battery (DB)/condensation nucleus counter (CNC) submicron-sizing system and a laser particle spectrometer. The penetrating particles through the GF/A and HEPA filters ranged from 0.10 to 0.18 mum in diamter. The values of penetration through the GF/A filter by two different particle measuring methods - the combined CNC/DB system and the laser particle spectrometer- were consistent with each other in the limited size from 0.12 to 0.42 mum. No significant difference between the penetration curve of DOP particles and that of ambient particles was observed. Neutralization of changes in particle surface with ^{85}Kr radiation yielded a higher penetration through the air filter. The collection efficiency was distinctly higher in ULPA media than HEPA filter media. The penetration through tandem filter was equal to the product of penetrations of each filter. Based on the above data, a relationship between decontamination factor (DF) and the efficieny was estimated. New standard particle size, in which the minimum DF is able to be easily obtained, was proposed. Experiments of multi-stage filtration system made it possible to experimentally indicate lower values of DF in the second and third stages, even if collection performance of each filter is the same. The suitability of numerical experiment was verified by filtration experiments with radioactive ^{198}Au aerosols. (Namekawa, K).

6980 (NUREG–1380) **Low-level radioactive waste research program plan.** O'Donnell, E.; Lambert, J. Nuclear Regulatory Commission, Washington, DC (USA). Div. of Engineering. Nov 1989. 67p. Sponsored by Nuclear Regulatory Commission. Available from NTIS, PC A04/MF A01; OSTI; INIS.

The Waste Management Branch, Division of Engineering, Office of Nuclear Regulatory Research, has developed a strategy for conducting research on issues of concern to the US Nuclear Regulatory Commission (NRC) in its efforts to ensure safe disposal of low-level radioactive waste (LLW). The resulting LLW research program plan provides an integrated framework for planning the LLW research program to ensure that the program and its products are responsive and timely for use in NRC's LLW regulatory program. The plan discusses technical and scientific issues and uncertainties

associated with the disposal of LLW, presents programmatic goals and objectives for resolving them, establishes a long-term strategy for conducting the confirmatory and investigative research needed to meet these goals and objectives, and includes schedules and milestones for completing the research. Areas identified for investigation include waste form and other material concerns, failure mechanisms and radionuclide releases, engineered barrier performance, site characterization and monitoring, and performance assessment. The plan proposes projects that (1) analyze and test actual LLW and solidified LLW under laboratory and field conditions to determine leach rates and radionuclide releases, (2) examine the short- and long-term performance of concrete-enhanced LLW burial structures and high-integrity containers, and (3) attempt to predict water movement and contaminant transport through low permeability saturated media and unsaturated porous media. 4 figs., 3 tabs.

6981 (ORNL–6557) **[ORNL Waste Management Research and Development Programs] annual progress report for the period October 1, 1987–September 30, 1988.** Dawson, M.M.; Pechin, W.H. (comps.). Oak Ridge National Lab., TN (USA). Oct 1989. 144p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC05-84OR21400. Order Number DE90004405. Available from NTIS, PC A07/MF A01; OSTI; INIS; GPO Dep.

The annual report of the Waste Management Research and Development programs describes work conducted at Oak Ridge National Laboratory (ORNL) in FY 1988. Major programs in this area include work for the Office of Civilian Radioactive Waste Management on high-level radioactive waste (HLW) management, both geotechnical studies related to a geologic repository and systems studies related to the entire system for management of spent fuel and HLW from the reactor to a monitored retrievable storage facility (if included) to delivery at a geologic repository for final emplacement. Transportation work is also described under separate programs for Transportation operations, research and development into the capabilities and requirements for HLW transportation casks, and Packaging and Transportation Compliance. Included in the report are accounts of ORNL work in the area of site surveys in the Uranium Mill Tailings Remedial Action Project and the Formerly Utilized Sites Remedial Action Project. Research and development (R&D) work conducted for the National Low-level Waste Management is included as is work sponsored by the US Department of Energy (DOE) Hazardous Waste and Remedial Actions Program. This report also describes waste management R&D conducted for other federal agencies, especially the Department of Defense, which has sponsored several demonstrations of advanced technologies for the remediation of sites contaminated by hazardous materials. 79 refs.

6982 (ORNL/FTR–2901) **[Low-level radioactive waste management techniques]: Foreign trip report, June 4, 1988–July 8, 1988.** Van Hoesen, S.D. (Oak Ridge National Lab., TN (USA)); Kennerly, J.M.; Williams, L.C.; Lingle, W.N.; Peters, M.S.; Darnell, G.R. Oak Ridge National Lab., TN (USA). 8 Aug 1988. 26p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC05-84OR21400. Order Number DE90003983. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The US team consisting of representatives of Oak Ridge National Laboratory (ORNL), Savannah River plant (SRP), Idaho National Engineering Laboratory (INEL), and the Department of Energy, Oak Ridge Operations participated in a training program on French low-level radioactive waste (LLW) management techniques. Training in the rigorous waste characterization, acceptance and certification procedures required in France was provided at Agence Nationale pour les Gestion des Dechets Radioactif (ANDRA) offices in Paris.

6983 (ORNL/TM–10992) **Evaluation of an in situ vitrification field demonstration of a simulated radioactive liquid waste disposal trench.** Spalding, B.P.; Jacobs, G.K. Oak Ridge National Lab., TN (USA). Oct 1989. 158p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC05-84OR21400. Order Number DE90004399. Available from NTIS, PC A11/MF A01 - OSTI; GPO Dep.

In July 1987, a field demonstration of in situ vitrification (ISV) was carried out at the Oak Ridge National Laboratory (ORNL). The project was a collaborative venture between ORNL and Battelle Pacific Northwest Laboratory (PNL) using the PNL pilot-scale processing unit. A 3/8-scale model of an ORNL radioactive liquid waste disposal trench was constructed and chemical additions of Cs_2CO_3 and $SrCO_3$ were used to simulate the ^{137}Cs and ^{90}Sr contained in the seven abandoned ORNL seepage disposal trenches. A 20-Mg mass of vitrified product was produced from the demonstration trench. The objectives of the demonstration were (1) to evaluate the operational performance of ISV within the local geologic and hydrologic regime with the earthen materials used in ORNL seepage trench construction; (2) to determine the soil retention factors (i.e., the ratio of the elemental amounts in the vitrified mass to that released to the process off-gas) for Cs and Sr so that the radiological safety for ISV application to large inventories of ^{137}Cs and ^{90}Sr can be assessed; and (3) to determine the durability of the resulting ISV product as a waste form and compare it to the durability of the form of ^{137}Cs and ^{90}Sr presently in the ORNL seepage trenches. 26 refs., 59 figs., 30 tabs.

6984 (ORNL/TM–11364) **Soils and geomorphology of the East Chestnut Ridge site.** Lietzke, D.A. (Lietzke (D.A.), Rutledge, TN (USA)); Ketelle, R.H.; Lee, R.R. Oak Ridge National Lab., TN (USA). Oct 1989. 39p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004369. Available from NTIS, PC A07/MF A01 - OSTI; GPO Dep.

Soil mapping of the East Chestnut Ridge site in conjunction with subsurface soil and rock coring provides an in-depth evaluation of the site and its suitability for disposal of wastes. Landforms and surface and subsurface hydrology, the natural, undisturbed, soil-saprolite-geohydrology system beneath the zone of engineering modifications provides for the ultimate containment of wastes and a means for the filtration and purification of any leachate before it reaches the aquifer. The surface location and extent of each geologic formation on the site were mapped. These locations correlated well with projections of subsurface contacts to the surface even through the criteria used by the pedologist and geologist to identify soil and rock from the same formation may be different. Soil thickness over bedrock of the Copper Ridge, Chepultepec, Longview, and Kingsport Formations is sufficient to provide considerable buffering between trench bottoms and groundwater or rock. Soil thickness over the Mascot Formation is comparatively thin, and pinnacles and ledges exposed on steeper sideslopes are common. Soil underlain by the Mascot Formation is not suited for a trench landfill. According to soil coring and active borrow pit observations, chert beds in the soil and saprolite are preferred zones of water flow. Construction of adequate clay liners beneath disposal units sited on the Longview dolomite may require placement and compaction of other native soils to achieve sufficiently low soil permeabilities. Karst geomorphic processes that initiated the formation of dolines evidently started several million years ago. Doline formation and enlargement is episodic, with short periods of activity followed by long periods of stability. Analysis of doline soil stratigraphy suggests that most of the large dolines on the site have been stable for most of the past 10,000 to 1000,000 years. 8 refs., 9 figs.

6985 (PNL–7131) **Nuclear Waste Treatment Program annual report for FY 1988.** Brouns, R.A.; Powell, J.A. (comps.). Pacific Northwest Lab., Richland, WA (USA). Nov 1989. 152p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC06-76RL01830. Order Number DE90004982. Available from NTIS, PC A08/MF A01; OSTI; INIS; GPO Dep.

Much emphasis continues to be on the transfer of remote design technology for components integral to the West Valley Demonstration Project's (WVDP) vitrification process. In addition to preparing equipment specifications and drawings, Pacific Northwest Laboratory (PNL) staff also participated in numerous design coordination meetings and reviews of drawings prepared by other WVDP contractors. Nearly 200 jumper drawings for the vitrification cell were prepared by this program in FY 1988. The remote jumpers connect vessels in the cell to each other for the transfer of solutions and provide for the flow of materials, instrumentation signals, and power from outside the cell. Analysis required in preparing the jumper designs involved balance, thermal stress, seismic, set-down stress, and displacement calculations. Design efforts were begun on the canister decontamination and swipe station and on the remote

maintenance station. Equipment selection and layouts of the vitrification off-gas treatment system, including a reamer to remotely clean the melter off-gas line, were finalized. Also finalized were the designs for the high-efficiency particulate air (HEPA) filter assemblies for heating, cooling and air conditioning of the vitrification cell.

6986 (PNL–7143) **Spent fuel acceptance scenarios devoted to shutdown reactors: A preliminary analysis.** Wood, T.W. (Pacific Northwest Lab., Richland, WA (USA)); Plummer, A.M.; Dippold, D.G.; Short, S.M. Pacific Northwest Lab., Richland, WA (USA). Oct 1989. 43p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-76RL01830. Order Number DE90004456. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Spent fuel acceptance schedules and the allocation of federal acceptance capacity among commercial nuclear power reactors have important operational and cost consequences for reactor operators. Alternative allocation schemes were investigated to some extent in DOE's MRS Systems Study. The current study supplements these analyses for a class of acceptance schemes in which the acceptance capacity of the federal radioactive waste management system is allocated principally to shutdown commercial power reactors, and extends the scope of analysis to include considerations of at-reactor cask loading rates. The operational consequences of these schemes for power reactors, as measured in terms of quantity of spent fuel storage requirement above storage pool capacities and number of years of pool operations after last discharge, are estimated, as are the associated utility costs. This study does not attempt to examine the inter-utility equity considerations involved in departures from the current oldest-fuel-first (OFF) allocation rule as specified in the "Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste." In the sense that the alternative allocations are more economically efficient than OFF, however, they approximate the allocations that could result from free exchange of acceptance rights among utilities. Such a process would result in the preservation of inter-utility equity. 13 refs., 9 figs., 9 tabs.

6987 (PTB-SE–24) **Amount of radioactive wastes in the Federal Republic of Germany - waste survey for the year 1988.** Brennecke, P.; Schumacher, J. Physikalisch-Technische Bundesanstalt, Braunschweig (Germany, F.R.). Abt. Sicherstellung und Endlagerung Radioaktiver Abfaelle. Jun 1989. 59p. (In German). Order Number DE90732496. Available from NTIS (US Sales Only), PC A04/MF A01.

On December 31, 1988, about 69 800 waste packages - about 40 700 m^3 - were stored in interim storage facilities. The unconditioned radioactive wastes amounted to about 11 700 m^3. The volume of the conditioned radioactive wastes amounted to about 40 700 m^3. Of this, the waste from nuclear research centres made up about 16 300 m^3, the waste from the operation of nuclear power plants about 12 900 m^3 and that from the reprocessing of spent fuel elements about 8 300 m^3. A prognosis was also made of the future amount of conditioned radioactive wastes. According to this forecast, the cumulated waste package volume of radioactive wastes with negligible heat generation will be approximately in the order of 173 400 m^3 up to the year 2000, whereas for heat-generating radioactive wastes a volume of about 5 800 m^3 is estimated. These figures already express the waste volume reduction according to modern conditioning techniques. In 1988 a capacity of about 123 800 m^3 for the interim storage of radioactive wastes was available in the Federal Republic of Germany. On December 31, 1988, an average of about 37% of this capacity was utilized by unconditioned and conditioned radioactive wastes. From the data on the expected amount of radioactive wastes and on the utilization factor of the interim storage facilities, it may be concluded that, taking an overall view, no bottlenecks in the interim storage of radioactive wastes with negligible heat generation are to be anticipated up to the planned operation of the Konrad repository in 1994. (orig./HP).

6988 (RHO-BWI–723TP01) **Near-Surface Test Facility Data Acquisition System: Test plan for qualification tests.** Dover, R.L.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. 19 Oct 1979. 28p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This document describes the Test Plan for Qualification Tests which is a sub-system of the Data Acquisition System for the Near Surface Test Facility.

6989 (RHO-BWI–810DD01) **Preconceptual repository design for basalt.** Patricio, J.G.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations; Agapito (J.F.T.) and Associates, Grand Junction, CO (USA). 5 Dec 1979. 807p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

These engineering report volumes comprise a subcontractors report describing the subsurface aspects of a preconceptual repository design in basalt. The subcontractor, J.F.T. Agapito and Associates, Incorporated, have not dispositioned all review comments, therefore, a review item record (DRR-B301-49) has been attached to indicate items requiring change.

6990 (RHO-BWI-AP–006) **Activity plan for Commonwealth Scientific and Industrial Research Organization Triaxial Hollow Inclusion Strain Cell measurements in the Near-Surface Test Facility: Revision 0.** Erb, D.B.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. Feb 1986. 22p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This activity plan outlines the overall test requirements for overcoring development tests at the Near-Surface Test Facility (NSTF) using the Commonwealth Scientific and Industrial Research Organization (CSIRO) Triaxial Hollow Inclusion Strain Cell. The testing is being conducted to field check both the overcoring equipment system and the CSIRO test instructions and to train Rockwell Hanford Operations (Rockwell) personnel. Improvements and modifications developed during the testing will be incorporated into the test instructions. 4 refs.

6991 (RHO-BWI-ATP–002) **Acceptance Test Procedure for the rock instrumentation system, Block Test No. 1, Step 2, Building 623-C.** Flesher, D.J.;;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. 1 Jul 1982. 22p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This document describes the acceptance tests to be conducted on the Block Test #1 instrumentation prior to running Block Test #1, Step 2.

6992 (RHO-BWI-CDR–002) **Conceptual Design Report, Exploratory Shaft Power Line and Substation, Project B-417.** Schroeder, B.K. (Kaiser Engineers Hanford Co., Richland, WA (USA)). Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations; Kaiser Engineers Hanford Co., Richland, WA (USA). Mar 1982. 68p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-82RL10367. Available from OSTI; INIS.

This project will provide a 13.8-KV, 3-phase electrical power line from substation B-251 to the ES site. The power line will be sized to carry the 6000 KVA power required to meet the construction and operations power requirements of the facility. The line will originate at an existing circuit breaker at the 13.8 KV switch gear at substation B-251 and will terminate at fused cutouts at the ES site. Wood poles will be used for the aerial support of the ~4.7 mi. transmission line. Joint use of the line by project B-316 is being considered. This part will provide transformation from 13.8 KV to 2.4 KV, transformer mounting, grounding grid for the entire substation, the substation fence, and connection between the primary side of the transformer and the 13.8 KV electrical line (last pole) provided by Part I. Switching stations, protective devices, and metering, which are normally part of a substation, will be provided by the ES project, B-314. This report includes drawings, cost estimates and schedules.

6993 (RHO-BWI-CR–005) **Conceptual design requirements for spent fuel, high-level wastes and transuranic waste packages.** Anderson, W.J.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. Feb 1982. 73p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This document defines site specific waste package design requirements for a repository in basalt in the format of Chapter 3.0 of

the BWIP Systems Specification. The basis for the waste package conceptual design requirements and discussions of waste package/repository design interfaces are presented as Appendices to the Specification. 27 refs., 3 figs., 8 tabs.

6994 (RHO-BWI-CR–015) **Preliminary performance requirements and criteria for the seal system of a nuclear waste repository in basalt.** Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. 1983. 100p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

Preliminary performance requirements and criteria for the sealing of shafts, tunnels, and boreholes in a nuclear waste repository in basalt are presented in this document. These performance requirements are derived from the regulations drafted by the US Environmental Protection Agency, the US Nuclear Regulatory Commission, the National Waste Terminal Storage Program Criteria for Mined Geologic Disposal of Nuclear Waste, and the Basalt Waste Isolation Project Principal Criteria Document. The preliminary performance requirements and criteria presented in this report will be used to develop a repository seal system conceptual design. As additional data are obtained the preliminary performance requirements and criteria contained in this document will be reviewed for their adequacy. 50 refs.

6995 (RHO-BWI-CR–018) **Draft waste acceptance requirements for the Basalt Waste Isolation Project.** Randklev, E.H.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. 27 Jun 1983. 107p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This document presents the waste acceptance requirements developed by the Basalt Waste Isolation Project for a nuclear waste repository located in basalt. Requirements and associated limits are presented for three high-level waste types: commercial high-level waste, commercial spent fuel, and Savannah River defense high-level waste. The information presented in this document represents the first stage in the development of waste acceptance specifications for a nuclear waste repository located in basalt. 33 refs., 1 tab.

6996 (RHO-BWI-CR–022-Rev.4) **Site Characterization Plan (SCP) conceptual design criteria document: Revision 4.** Naiknimbalkar, N.M.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. 19 May 1986. 279p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This SCP Conceptual Design Criteria Document was developed to guide engineering effort for Engineering Study No. 10, the supporting document for Chapter 6 of the SCP. The document provides regulatory design guidance, design rationale derived from the Generic Requirements for a Mined Geological Disposal System document, site-specific criteria, and design assumptions. Appendices were added to provide additional information on geology and seals design. 24 figs., 15 tabs.

6997 (RHO-BWI-DCR–001) **Design criteria and calculations for 112 inch casing for the BWIP [Basalt Waste Isolation Project] exploratory shaft.** Brockman, P.K.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations; Kaiser Engineers (California) Corp., Oakland, CA (USA); Parsons, Brinckerhoff, Quade and Douglas, Inc., Oakland, CA (USA). 12 May 1982. 9p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This document establishes the design criteria and supporting calculations for the 112" I.D. steel casing.

6998 (RHO-BWI-DCR–005) **Design criteria and supporting calculations for the drill rig foundation.** Brockman, P.K.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. 24 Sep 1982. 61p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This document establishes the Design Criteria and Supporting Calculations for the Drill Rig Foundation.

6999 (RHO-BWI-DCR–009) **Exploratory shaft Phase 1, Title 2 design: Calculations, September 1983: Structural.** Schroeder, B.K.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations; Kaiser Engineers (California) Corp., Oakland, CA (USA); Parsons, Brinckerhoff, Quade and Douglas, Inc., Oakland, CA (USA). 1983. 557p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This document describes structural calculations for the Exploratory Shaft, Phase I.

7000 (RHO-BWI-DCR–010) **Exploratory shaft Phase 1, Title 2 design: Calculations, September 1983: HVAC, mechanical and mining.** Schroeder, B.K.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations; Kaiser Engineers (California) Corp., Oakland, CA (USA); Parsons, Brinckerhoff, Quade and Douglas, Inc., Oakland, CA (USA). 1983. 367p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This document contains the HVAC, Mechanical & Mining calculations for the Exploratory Shaft, Phase I.

7001 (RHO-BWI-DP–001) **BWIP data package for reference solubility and Kd values: Revision A-0.** Salter, P.F.; Jacobs, G.K. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. 6 Jan 1983. 9p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This data package defines the solubility and Kd values to be used for all modeling activities related to the migration of radionuclides through the geologic setting, or any other path where the geochemical conditions are appropriate. The set of conservative and expected solubilities and Kd values for modeling purposes are compared to available thermodynamic calculations and experimental data, respectively. Where no data or calculations are available, estimates of solubilities and Kd values have been made. 11 refs., 2 tabs.

7002 (RHO-BWI-DP–008) **Reference stratigraphy: Revision A-0.** Landon, R.D. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. 25 May 1983. 7p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This data package contains information on interpretations of rock stratigraphic units in the upper Grande Ronde, Wanapum and Saddle Mountains Basalts in the Cold Creek syncline. This data package contains correlations for Boreholes DC-2, -3, -4, -8, -12, RRL-2, -6, -14.

7003 (RHO-BWI-DP–011-Rev.2) **Geologic thickness data: Candidate repository horizons: Revision 2.** Cross, R.W.; Fairchild, K.R. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. 27 Feb 1985. 72p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This data package contains information on the thickness of the Umtanum, McCoy Canyon, Cohassett, and Rocky Coulee flows and their intraflow structures in 20 boreholes and 2 surface sections in the Pasco Basin. Thickness data are for total flow, flow top, entablature, and colonnade (or just flow top and dense interior in some cases). Summary figures which contain descriptions and footages are included.

7004 (RHO-BWI-DP–012) **BWIP data package for reference physicochemical conditions.** Early, T.O. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. 19 Apr 1983. 14p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This package defines the physicochemical conditions expected to prevail in a closed nuclear waste repository located in the Umtanum, McCoy Canyon or Cohassett flows of the Columbia River Basalts at the Hanford Site. The estimated conditions result from the combination of experimental data, theoretical calculations, in situ measurement, and field observations. Equations are provided for the estimation of temperature and pressure as a function of depth, and pH and Eh as functions of temperature. 13 refs., 1 fig., 2 tabs.

7005 (RHO-BWI-DP–035-Rev.3) **Deep borehole stratigraphic correlation charts: Revision 3.** Landon, R.D. Rockwell

International Corp., Richland, WA (USA). Rockwell Hanford Operations. Feb 1985. 244p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This data package contains updated information on stratigraphic correlations for deep boreholes within the Pasco Basin.

7006 (RHO-BWI-DP–041-Rev.1) **Rock mechanics data package: Revision 1.** Sublette, W.R. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. Jan 1986. 78p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This data package provides a summary of available laboratory and in situ stress field test results from site characterization investigations by the Basalt Waste Isolation Project Modeling and Analysis Group. The objective is to furnish rock mechanics information for use by Rockwell Hanford Operations and their subcontractors in performance assessment and engineering studies. This release includes Reference Repository Location (RRL) site specific laboratory and field test data from boreholes RRL-2, RRL-6, and RRL-14 as well as previous Hanford wide data available as of April, 1985. 25 refs., 9 figs., 16 tabs.

7007 (RHO-BWI-DP–051-Rev.2) **Hydraulic property data from selected test zones on the Hanford Site.** Strait, S.R.; Mercer, R.B. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. May 1987. 31p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This data package contains a summary of hydraulic properties, as determined from analysis of hydrologic test data, from selected test zones within the Saddle Mountains, Wanapum, and Grande Ronde Basalts. The information within this package includes: borehole, stratigraphic horizon, use code, isolated test interval, effective test interval, transmissivity, hydraulic head, and the uncertainty of the hydraulic head value. The hydraulic properties are considered preliminary and subject to change with further analysis and subsequent documentation. The observed hydraulic head values are uncorrected, field derived values. 21 refs., 1 tab.

7008 (RHO-BWI-DP–053) **Characterization of reference Umtanum and Cohassett basalt.** Allen, C.C.; Johnston, R.G.; Strope, M.B. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. Feb 1985. 47p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

The Basalt Waste Isolation Project (BWIP) Materials Testing Group (MTG) provides large quantities of reference basalt for testing waste package materials under repository conditions, site sorption characteristics and other experimental purposes. This document describes the reference rock materials currently used in testing, namely entablature and colonnade basalt from the Umtanum and Cohassett flows. The data include sampling locations, bulk chemical composition, modal percentages of major phases, and the chemical and mineralogical compositions of these phases. 8 refs., 17 figs., 15 tabs.

7009 (RHO-BWI-DP–054) **Water-level, downhole pressure and atmospheric pressure measurements from piezometer clusters DC-19, DC-20 and DC-22, September 1 through September 30, 1984.** Bryce, R.W.; Yeatman, R.A. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. Nov 1984. 322p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This data package reports the September 1 through September 30, 1984, water-level, downhole pressure, atmospheric pressure data from the DC-19, DC-20 and DC-22 piezometers set in selected horizons at the Hanford Site. Included in the package is information concerning borehole locations, hydrogeologic units being monitored, depth intervals of monitored zones, water-level measurements, downhole pressure and atmospheric pressure measurements. Also included are summary water-level hydrographs for each piezometer. 4 refs., 33 figs., 2 tabs.

7010 (RHO-BWI-DP–056) **Water-level, downhole pressure and atmospheric pressure measurements from piezometer clusters DC-19, DC-20 and DC-22, October 1 through October 31, 1984.** Bryce, R.W.; Yeatman, R.A. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. Dec 1984. 342p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This data package reports the October 1 through October 31, 1984, water-level data from the DC-19, DC-20 and DC-22 piezometers set in selected horizons at the Hanford Site. Included in the package is information concerning borehole locations, hydrogeologic units being monitored, depth intervals of monitored zones, water-level measurements, downhole pressure and atmospheric pressure measurements. Also included are summary water-level hydrographs for each piezometer. 15 refs., 33 figs., 4 tabs.

7011 (RHO-BWI-DP–058) **Water-level, downhole pressure and atmospheric pressure measurements from piezometer clusters, DC-19, DC-20 and DC-22, November 1 through November 30, 1984.** Bryce, R.W.; Yeatman, R.A. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. Jan 1985. 306p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This data package reports the November 1 through November 30, 1984, water-level, downhole pressure, atmospheric pressure data from the DC-19, DC-20 and DC-22 piezometers set in selected horizons at the Hanford Site. Included in the package is information concerning borehole locations, hydrogeologic units being monitored, depth intervals of monitored zones, water-level measurements, downhole pressure and atmospheric pressure measurements. Also included are summary water-level hydrographs for each piezometer. 16 refs., 33 figs., 3 tabs.

7012 (RHO-BWI-DR–001-Vols.1-2-Rev.2) **Exploratory Shaft, Phase 1: Project B-314, Title 2 design report, system design description: Volumes 1 and 2: Revision 2.** Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations; Kaiser Engineers (California) Corp., Oakland, CA (USA); Parsons, Brinckerhoff, Quade and Douglas, Inc., Oakland, CA (USA). 21 Jun 1984. 237p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-80RL10000. Available from OSTI; INIS.

This two-volume report is submitted as part of the Exploratory Shaft – Phase 1, design work effort. Volume 1 contains a description of the structures, systems, and components that constitute the project; background information and a criteria summary are also included, as are sections on hazards, quality assurance, interfaces, and specifications. Volume 2 does not reflect the most current drawings associated with project design. These drawings have been revised during construction and therefore should be used only to supplement Volume 1. The most current drawings are released by Data Management under the Engineering Order System.

7013 (RHO-BWI-ER–011) **Appraisal of several empirical rock mass classification methods for estimating tunnel support requirements in a geologic high-level waste.** Kim, K. (Pacific Northwest Lab., Richland, WA (USA)). Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations; Pacific Northwest Lab., Richland, WA (USA). 20 Mar 1985. 83p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This report considers three different empirical methods for estimating the rock mass condition and support requirements for the Hanford Site. The three methods employed are (1) rock structure rating model, (2) rock mass rating, and (3) Q system. The site specific conditions at the Hanford Site are used to estimate the support requirements for an underground high-level waste repository in basalt. The suitability of each method is considered by comparing the case history site conditions from each empirical method with the conditions at the Hanford Site. The generalized support system recommended by the empirical methods for the Hanford Site is evaluated using a rock support interaction analysis. 3 refs., 19 figs., 13 tabs.

7014 (RHO-BWI-ER–011-Rev.1) **Appraisal of several empirical rock mass classification methods for estimating tunnel support requirements in a geologic high-level waste: Revision 1.** Kim, K. (Pacific Northwest Lab., Richland, WA (USA)). Rockwell

International Corp., Richland, WA (USA). Rockwell Hanford Operations; Pacific Northwest Lab., Richland, WA (USA). 20 Mar 1985. 83p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This report considers three different empirical methods for estimating the rock mass condition and support requirements for the Hanford Site. The three methods employed are (1) rock structure rating model, (2) rock mass rating, and (3) Q system. The site specific conditions at the Hanford Site are used to estimate the support requirements for an underground high-level waste repository in basalt. The suitability of each method is considered by comparing the case history site conditions from each empirical method with the conditions at the Hanford Site. The generalized support system recommended by the empirical methods for the Hanford Site is evaluated using a rock support interaction analysis. 39 refs., 19 figs., 13 tabs.

7015 (RHO-BWI-ER–012-Rev.1) **Rock mass quality and support recommendations for basalt at the candidate repository horizon, based on the Q-system: Revision 1.** Barton, N. (Terra Tek, Inc., Salt Lake City, UT (USA));. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations; Terra Tek, Inc., Salt Lake City, UT (USA). Apr 1986. 106p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

An analysis of the Q-system of rockmass characterization and tunnel support selection and its application to the candidate repository horizon is provided. The range of rockmass qualities, tunnel sizes and tunnel depths which constitute the Q-system database are reviewed and related to the quality of the candidate repository horizon, rock conditions equivalent to those in the candidate horizon are thoroughly documented. A detailed review of pertinent BWIP documents was undertaken to estimate general conditions and possible extreme conditions, and resulted in determining an extreme range of Q from 0.05 to 10 and a design range of 0.4 to 4. Detailed rock reinforcement recommendations, incorporating appropriate reinforcement for typical and extreme colonnade and entablature, were derived for roofs, walls and intersections in all planned tunnels. 35 refs., 31 figs., 19 tabs.

7016 (RHO-BWI-ER–013) **Fault tree analysis for large hole drilling.** Webster, C.T. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. 1985. 16p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

The Fault Tree Analysis for Large Hole Drilling is an analysis of actions to be taken as a result of off normal conditions which may occur during large hole drilling operations. The fault tree analysis is organized according to information available during drilling.

7017 (RHO-BWI-ES–020) **Two-phase repository feasibility study.** Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations; Morrison-Knudsen Co., Inc., Boise, ID (USA); Kaiser Engineers (California) Corp., Oakland, CA (USA); Parsons, Brinckerhoff, Quade and Douglas, Inc., Oakland, CA (USA). 17 Aug 1984. 271p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This feasibility study was undertaken to verify the validity of the two-phase repository development concept and to ensure that the Nuclear Waste Policy Act of 1982 schedules for emplacement of waste in the first repository starting in 1998 can be met by the Basalt Waste Isolation Project (BWIP). The primary conclusion of this study is: the two-phase repository development is a viable concept to enable first waste emplacement at the Hanford Site by January 1998 and full-scale waste emplacement starting in February 2001. 17 refs., 47 figs., 25 tabs.

7018 (RHO-BWI-ES–023) **Task 5, engineering study No. 9, underground repository layout: Project B-301.** Black, M.T. (Kaiser Engineers (California) Corp., Oakland, CA (USA)). Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations; Kaiser Engineers (California) Corp., Oakland, CA (USA); Parsons, Brinckerhoff, Quade and Douglas, Inc., Oakland, CA (USA). Jan 1985. 474p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-80RL10000. Available from OSTI; INIS.

This engineering study provides a single phase concept of the underground layout for a Nuclear Waste Repository in Basalt. The study basis is provided by the functional criteria and integrated design criteria contained in Appendix E. The formulation of these criteria was generally based on the DOE Draft Generic Requirements Document, Rock Mechanics Data Package, Horizon Identification Report, and the Draft Waste Package Concepts Study. Generally, this study concluded that a rectangular single level layout with a central shaft pillar (there are two outlying shafts) is the best conceptual configuration based on the above criteria. 28 figs., 26 tabs.

7019 (RHO-BWI-TC–026-Rev.2) **Drilling and completion specifications for Wanapum (Type W) and Grande Ronde (Type GR) multilevel piezometer nest boreholes: Revision 2.** Brown, W.R.; Jones, R.L.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. Mar 1986. 73p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

Wanapum (Type W) and Grande Ronde (Type GR) multilevel piezometer boreholes will provide information on hydraulic heads in seven horizons adjacent to the reference repository location. In addition, the boreholes will be used to determine horizontal and vertical flow rates, and identify possible geologic structures.. This specification includes details for drilling, piezometer design, hydrologic testing, and hydrochemical sampling of the boreholes. It includes drilling requirements, design, and installation procedures for the Type W and Type GR-series piezometer nests, intervals selected for head monitoring and schedules for drilling and piezometer installation. Specific drilling and piezometer installation specifications for the first two boreholes in this series, DC-23W and DC-23GR, are also included. 5 refs., 11 figs., 10 tabs.

7020 (RHO-BWI-TD–001) **Block Test Step 1 report.** Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. Jan 1982. 112p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This document provides details of the operation of Block Test 1 Step 1, analysis of the results of Step 1, and predictive analysis and recommendations for Step 2. Step 1 consisted of a single horizontal slot cut in the rock face designed to measure uniaxial rock mass deformation at varying temperatures and pressures; and to evaluate the test set up and instrument performance. Step 2 shall consist of four slots cut in a square in the rock face, designed to measure biaxial rock mass deformation, thermal conductivity, and coefficient of thermal expansion at varying temperatures and confining pressures. 7 refs., 46 figs., 16 tabs.

7021 (RHO-BWI-TD–009) **Large diameter shaft development basalt drillability tests.** Krug, A.D. (Colorado School of Mines, Golden, CO (USA));. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations; Colorado School of Mines, Golden, CO (USA). Mar 1984. 215p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

The objective of this work was to provide a preliminary evaluation of the performance and wear characteristics of various cutter types, and to provide initial estimates of drilling rates, bit thrust, torque, and power requirements for the drilling of large diameter shafts in basalt. 20 refs., 74 figs., 7 tabs.

7022 (RHO-BWI-TD–017) **Results of thermomechanical tests on specimens of Hanford basalts.** Meyer, L. (Lawrence Berkeley Lab., CA (USA));. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations; Lawrence Berkeley Lab., CA (USA). 30 Sep 1982. 65p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This report presents the results of laboratory tests and analysis performed by the Lawrence Berkeley Laboratories of the University of California Berkeley to measure and calculate the specific heats, coefficients of thermal expansion, coefficients of thermal conductivity, and thermal diffusivities of specimens of flood basalts from Hanford, Washington. The specimens were prepared from drill cores provided by Rockwell Hanford Operations. All cores and rock

fragments were returned to Rockwell after testing was completed. 7 refs.

7023 (RHO-BWI-TD–019) **Physical properties of Dowell Chemical Seal Ring.** Benny, H.L.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. Jul 1985. 12p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This document outlines the tests, procedures, and results of an evaluation program for Dowell's "Chemical Seal Ring." The testing reported here deals with the physical properties of density, compression, tensile strength, elongation, and a push-out/bond strength test. Dowell's "Chemical Seal Ring" is proposed as a gasket-like seal between grout layers in the annulus around the Exploratory Shaft steel liner. 4 refs., 1 fig., 4 tabs.

7024 (RHO-BWI-TI–059) **Pre-test analysis of Step 2 of the jointed block test: Supporting document.** Brady, B.H.G. (Minnesota Univ., Minneapolis, MN (USA). Mineral Resources Research Center); Hart, R.D.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations; Minnesota Univ., Minneapolis, MN (USA). Mineral Resources Research Center. 30 Sep 1981. 65p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

The most important rock property to be obtained from Step 2 of the Jointed Block Test (JBT) is the bulk modulus of elasticity of Pomona basalt. The purpose of the JBT is to develop testing techniques which will allow determination of this modulus. The main concern of this report is to define loading conditions for Step 2 of the JBT which are calculated to preclude specimen disturbance (movement), which would make it impossible to determine the modulus of elasticity of the undisturbed rock specimen. Issues considered include the likely effect of specimen disturbance on rock mass deformation properties, and an approximate specification of applied loads to prevent nonlinear effects. The results of a comprehensive three-dimensional elastic analysis of block response to various sets of applied surface tractions are presented and discussed. 7 refs., 41 figs.

7025 (RHO-BWI-TI–167) **Borehole RRL-6 report.** Patterson, J.K. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. Dec 1983. 81p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

Borehole RRL-6 was drilled to provide geologic, hydrologic and rock mechanic data on the candidate horizons in the vicinity of the reference repository location. These activities are part of the Basalt Waste Isolation Project's subsurface characterization activities. This report summarizes the drilling and coring operations, geologic logging, geophysical logging and hydrologic testing at borehole RRL-6. 11 refs., 7 figs., 5 tabs.

7026 (RHO-BWI-TP–002) **Test plan for Phase 2, Nuclear waste tests: Supporting document.** St. Laurent, D.R. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. Feb 1981. 28p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This document provides general details of the Spent Fuel and Vitrified Waste Tests to be conducted as part of the Phase 2 program in the Near-Surface Test Facility (NSTF). Two spent fuel canisters and one vitrified waste canister will be transported to and emplaced within the NSTF in specially prepared boreholes in the basalt. This test will demonstrate the ability to emplace nuclear waste in basalt; will investigate the validity of using electrical heaters to simulate nuclear waste in basalt; and will provide information on the thermal, mechanical, and radiation interaction between nuclear waste and basalt over a three-year test period. 9 refs., 6 figs., 2 tabs.

7027 (RHO-BWI-TP–005) **Test plan for Shallow Borehole Plugging Tests.** Cashman, J.M.;. Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. 4 Feb 1981. 114p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

This test plan describes the Shallow Borehole Plugging Tests to be conducted at Gable Mountain. Part I of the test plan provides the objective, scope, and justification of the tests and a brief summary of proposed advanced tests. Part II provides a description of the tests, equipment, materials, test installation procedures, operational procedures and data analysis approach. 6 refs., 45 figs., 4 tabs.

7028 (RHO-BWI-TP–007) **Test plan for exploratory shaft: Phase 1 and Phase 2.** Rockwell International Corp., Richland, WA (USA). Rockwell Hanford Operations. Oct 1982. 105p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-77RL01030. Available from OSTI; INIS.

A test plan for an Exploratory Shaft (ES) in the Columbia River basalts at the reference repository location (RRL) is presented in two phases. Phase I will provide in situ characterization of the candidate repository horizon selected for breakout and provide information to support a Test and Evaluation Facility decision. 11 refs., 24 figs., 23 tabs.

7029 (SAND–89-0590C) **The Yucca Mountain Project repository sealing program.** Fernandez, J.A.; Hinkebein, T.E. Sandia National Labs., Albuquerque, NM (USA). [1989]. 7p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-890736–74: 30. annual meeting of the Institute of Nuclear Materials Management, Orlando, FL (USA), 9-12 Jul 1989). Order Number DE90003923. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Yucca Mountain is being characterized for the development of a high-level nuclear waste repository. The repository is planned to be located in the unsaturated zone in fractured, welded tuff. Sealing of the repository is one element of the Yucca Mountain Project. This paper presents a description of the current sealing design options, design requirements, and the design constraints. Design options for the shafts include anchor-to-bedrock seals, shaft fill, and settlement plugs; in the underground facility, they include drift seals, drainage channels, sumps, and bulkheads. Design requirements are those quantitative requirements imposed on the sealing design options to achieve a desired level of performance. For example, a design requirement could be a restriction on the hydraulic conductivity of a design option. Constraints are restrictions placed on the repository design by the sealing design. An example of a constraint could be establishing the drainage pattern to direct flow from emplacement drifts to nonemplacement drifts. As (1) additional hydrogeologic data are obtained through site characterization, (2) approaches to allocating performance to various subsystems within the Yucca Mountain Project are refined, and (3) the exploratory shafts and the associated testing results are developed, the design requirements and constraints may be modified and used in developing the License Application Design.

7030 (SAND–89-0591C) **Initial evaluation of sealing materials for the Yucca Mountain project.** Hinkebein, T.E.; Fernandez, J.A. Sandia National Labs., Albuquerque, NM (USA). [1989]. 6p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-890736–73: 30. annual meeting of the Institute of Nuclear Materials Management, Orlando, FL (USA), 9-12 Jul 1989). Order Number DE90003921. Available from NTIS, PC A02/MF A01 - OSTI.

The material selection process that has been used to determine candidate seal materials for the high-level nuclear waste repository at Yucca Mountain is described here. This process includes the development of a logic for the initial selection and subsequent refinements in the selection of materials. Each refinement or screen examines whether candidate seal materials possess several physical and chemical properties that are determined from seal design requirements. Each screen provides a basis for materials performance, testing, and analysis. The first screen identified broad materials groups (such as cementitious and earthen materials) and explained why other materials (such as ceramics and metals) are not being evaluated in current testing. The second screen identified specific material types such as "high-temperature concrete" or "low-permeability crushed rock/clay" for each of the seal components that may be included in the design. A review of the properties of these candidate sealing materials is also presented. Finally a materials recommendation summary resulting from the second screen is presented. 11 refs., 2 tabs.

7031 (SAND–89-0734C) **Cost-benefit assessment of the seismic design of the tuff repository waste handling facilities.** Subramanian, C.V. Sandia National Labs., Albuquerque, NM (USA). [1989]. 11p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-8910192–17: 2. DOE natural phenomena hazards mitigation conference, Knoxville, TN (USA), 3-5 Oct 1989). Order Number DE90003922. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This paper summarizes a cost-benefit assessment of the seismic design of the waste-handling facilities associated with the prospective high-level waste repository at Yucca Mountain, Nevada. It provides a very brief description of the methodology used and the costs and benefits of varying design levels for vibratory ground motions and surface fault displacements for structures, components, and equipment that are important to safety in the waste-handling facilities. 3 refs., 7 figs.

7032 (WSRC-RP–89-1015) **Waste site assessment report: New TNX Seepage Basin.** Nichols, R.L. Westinghouse Savannah River Co., Aiken, SC (USA). 5 Oct 1989. 170p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. Order Number DE90003905. Available from NTIS, PC A08/MF A01 - OSTI; GPO Dep.

This report was prepared to describe the physical characteristics of the New Seepage Basin at the Savannah River Site (SRS) TNX facility, assess the extent and degree of contamination, and describe the development and evaluation of closure options for the basin. Background information is taken from two publications: DPST-85-698, "Environmental Information Document – New TNX Seepage Basin" (EID), and DPSTD-88-1, "Technical Data Summary – Chemical Characterization of Sediments and Groundwater at the New TNX Seepage Basin" (TDS). The remainder of this section is a summary of the results of the seepage basin closure options analysis. 12 refs., 14 figs., 10 tabs.

7033 (WSRC-RP–89-1059) **Fish survey of Pen Branch and Indian Grave Branch.** Mealing, H.G. (Normandeau Associates, Inc., Aiken, SC (USA). Southeastern Regional Office); Heuer, J.H. Westinghouse Savannah River Co., Aiken, SC (USA); Normandeau Associates, Inc., Aiken, SC (USA). Southeastern Regional Office. Mar 1989. 12p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. (NAI-SR–101). Order Number DE90004268. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The objective of this ongoing study is to provide additional information for characterization of the fish communities of Pen Branch and Indian Grave Branch prior to the restart of K-Reactor.

7034 (WSRC-tr–134) **Research and development on the partitioning of high-level radioactive waste.** Kubota, Masamitsu (Japan Atomic Energy Research Inst., Tokyo (Japan)). 20p. Translated from Nippon Genshiryoku Gakkaishi; 29: No. 9, 775-782(Sep 1987). : ([1989]). Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035.

The object of research and development on partitioning is to separate transuranic elements, strontium, cesium, and the like from high-level wastes and, by carrying out treatment suited to the properties of each, to enhance the safety of high-level waste disposal, lower the amount of waste product generated, and assist in the effective utilization of [these elements] as resources. This article discusses research and development on the partitioning of high-level wastes, focusing in particular on the elements that are partitioned and the status of research and development efforts that have been conducted in Japan and abroad. 19 refs., 5 figs., 2 tabs.

7035 **Plasma processing and synthesis of materials.** Materials Research Society symposia proceedings. Volume 98. Apelian, D.; Szekely, J. 435p. Materials Research Society, Pittsburgh, PA (1987). (CONF-8704267–: Materials Research Society symposium on plasma processing and synthesis of materials, Anaheim, CA (USA), 21 Apr 1987).

These proceedings compile papers about plasma. Topics include: Plasma arc spraying, vacuum melting, plasma melters for nuclear waste vitrification, thermal degradation of metal oxides in plasma, electrohydrodynamics, laser-induced fluorescence, measurements of temperature in plasma, and modeling and diagnostics in plasma processing.

7036 **Future directions for separation science in nuclear and radiochemistry.** Pruett, D.J. (Oak Ridge National Lab., Oak Ridge, TN (US)). pp. 469 of Chemical separations. King, C.J.; Navratil, J.D. Litarvin Literature, Arvada, CO (1986). DOE Contract AC05-84OR21400. (CONF-860411–: 1. international conference on separations science and technology, New York, NY (USA), 15-17 Apr 1986).

Solvent extraction and ion exchange have been the most widely used separation techniques in nuclear and radiochemistry since their development in the 1940s. Many successful separations processes based on these techniques have been used for decades in research laboratories, analytical laboratories, and industrial plants. Thus, it is easy to conclude that most of the fundamental and applied research that is needed in these areas has been done, and that further work in these mature fields is unlikely to be fruitful. A more careful review, however, reveals that significant problems remain to be solved, and that there is a demand for the development of new reagents, methods, and systems to solve the increasingly complex separations problems in the nuclear field. Specifically, new separation techniques based on developments in membrane technology and biotechnology that have occurred over the last 20 years should find extensive applications in radiochemical separations.

7037 **Development and operation of a unique conversion/solidification process for highly radioactive and fissile uranium.** McGinnis, C.P. (Oak Ridge National Lab., TN (USA). Chemical Technology Div.); Collins, E.D.; Hall, R.; Johnson, J.K.; Krichinsky, A.M.; Patton, B.D.; Shor, J.T.; Vedder, R.J. *Nuclear Technology (USA)*, 77(2): 210-219 (May 1987). DOE Contract AC05-84OR21400.

A unique evaporation/thermal denitration process was developed, operated, and maintained successfully to permit the solidification and safe storage of –1000 kg of highly radioactive and fissile uranium, containing –75% ^{235}U, –10% ^{233}U, and –140 ppm ^{232}U. The project, called the Consolidated Edison Uranium Solidification Program, was carried out to prepare a stable uranium form for long-term, safe storage. During the project, the uranium nitrate solution was divided into –400 batches, which were successfully processed. Details of the process development, equipment maintenance, and operating expertise are described.

0530 Environmental Aspects

Refer also to citation(s) 6959, 6960, 6970, 6973, 6975, 6976, 6977, 6979, 6980, 6981, 6982, 6983, 6985, 6987, 6988, 6989, 6990, 6991, 6992, 6993, 6994, 6995, 6996, 6997, 6998, 6999, 7000, 7001, 7002, 7003, 7004, 7005, 7006, 7007, 7008, 7009, 7010, 7011, 7012, 7013, 7014, 7015, 7016, 7017, 7018, 7019, 7020, 7021, 7022, 7023, 7024, 7025, 7026, 7027, 7028, 7029, 7030, 7031, 7032

0540 Health and Safety

Refer also to citation(s) 7576, 7587, 8556, 9007

7038 (ORNL/EIS–154/V10) **Nuclear facility decommissioning and site remedial actions: Volume 10: A selected bibliography.** Owen, P.T.; Knox, N.P.; Ferguson, S.D.; Fielden, J.M.; Schumann, P.L. Oak Ridge National Lab., TN (USA). Sep 1989. 377p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. Order Number DE90003943. Available from NTIS, PC A17/MF A01; OSTI; INIS; GPO Dep.

The 576 abstracted references on nuclear facility decommissioning, uranium mill tailings management, and site remedial actions constitute the tenth in a series of reports prepared annually for the US Department of Energy's Remedial Action Programs. Citations to foreign and domestic literature of all types–technical reports, progress reports, journal articles, symposia proceedings, theses, books, patents, legislation, and research project descriptions–have been included. The bibliography contains scientific, technical, economic, regulatory, and legal information pertinent to the US Department of Energy's Remedial Action Programs. Major sections are (1) Surplus Facilities Management Program, (2) Nuclear Facilities

Decommissioning, (3) Formerly Utilized Sites Remedial Action Program, (4) Facilities Contaminated with Naturally Occurring Radionuclides, (5) Uranium Mill Tailings Remedial Action Program, (6) Uranium Mill Tailings Management, (7) Technical Measurements Center, and (8) General Remedial Action Program Studies. Within these categories, references are arranged alphabetically by first author. Those references having no individual author are listed by corporate affiliation or by publication description. Indexes are provided for author, corporate affiliation, title work, publication description, geographic location, subject category, and keywords.

7039 (PNL–6976) **324 and 325 Building hot cell cleanout program: Decontamination of C-Cell.** Katayama, Y.B.; Holton, L.K. Jr. Pacific Northwest Lab., Richland, WA (USA). Oct 1989. 24p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC06-76RL01830. Order Number DE90004347. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

During FY 1989 the decontamination of C-Cell of Hanford's 324 Building was completed as part of the 324 and 325 Building Hot Cell Cleanout Program sponsored by the DOE Nuclear Energy's Surplus Facilities Management Program. The decontamination effort was completed using a series of remote and contact decontamination techniques. Initial radiation readings in C-Cell averaged 50 rad/hr and were reduced remotely to less than 200 mrad/hr using an alkaline foam cleaner followed by a 5000-psi water flush. Contact decontamination was then permissible using ultra high-pressure water, at 36,000 psi, further reducing the average radiation level in the cell to less than 86 mrem/hr. The approach used in decontaminating C-Cell resulted in a savings in radiation exposure of 87% and a cost savings of 39% compared to a hands-on procedure used in A-Cell, 324 Building in 1987. The radiation dose and the costs to achieve a 244-fold reduction in radiation contamination were 1.65 mrem per ft^2 and $96 per ft^2 of cell surface area. 14 figs., 4 tabs.

7040 (PNL-SA–17293) **Holden Mine Rehabilitation Project.** Gephart, J.M.; Walters, W.H. Pacific Northwest Lab., Richland, WA (USA). Aug 1989. 5p. Sponsored by U.S. DOE Environment Health & Safety. DOE Contract AC06-76RL01830. Order Number DE90004117. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The purpose of the Holden Mine Project is to rehabilitate the mine tailings and piles associated with activities at the Holden Mine from 1938 until its closure in 1957. Rehabilitation is necessary to reduce existing and potentially adverse environmental effects. The Holden Mine tailings piles have been designated a moderately hazardous site by the Washington State Department of Ecology because of their potential for leaching into nearby Railroad and Copper creeks and the low pH of the water emerging from the mine entrance. The site is listed as a Category C1 Site, indicating the presence of hazardous substances confirmed by laboratory or field tests. 7 figs.

7041 (PNL-SA–17455) **The observational approach for site remediation at federal facilities.** Myers, R.S. (Pacific Northwest Lab., Richland, WA (USA)); Gianti, S.J. Pacific Northwest Lab., Richland, WA (USA). Nov 1989. 14p. Sponsored by U.S. DOE Environment Health & Safety. DOE Contract AC06-76RL01830. (CONF-8911152–1: 10. HMCRI's national conference and exhibition, Washington, DC (USA), 27-29 Nov 1989). Order Number DE90003635. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The observational approach, developed by geotechnical engineers to cope with the uncertainty associated with subsurface construction such as tunnels and dams, can be applied to hazardous waste site remediation. During the last year, the observational approach has gained increasing attention as a means of addressing the uncertainties involved in site remediation. In order to evaluate the potential advantages and constraints of applying the observational approach to site restoration at federal facilities, a panel of scientists and engineers from Pacific Northwest Laboratory and CH2M Hill was convened. Their review evaluated potential technical and institutional advantages and constraints that may affect the use of the observational approach for site remediation. This paper summarizes the panel's comments and conclusions about the application of the observational approach to site remediation at federal facilities. Key issues identified by the panel include management of uncertainty, cost and schedule, regulations and guidance, public involvement, and implementation. 5 refs.

7042 (RFP–4384) **General safety guidelines for the design of high-hazard (non-reactor) facilities at Rocky Flats Plant.** Restrepo, L.F. Rockwell International Corp., Golden, CO (USA). Rocky Flats Plant. [1989]. 65p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP03533. Order Number DE90003811. Available from NTIS, PC A04/MF A01 - OSTI.

This document provides guidance in the identification of safety-related systems and equipment, their safety classification, and the applicability of requirements that shall be used in the design, construction, fabrication, and procurement of these items. As such, this document is geared to the designer and the safety analyst. First, general safety criteria that serve as the bases for all safety classification are presented, as well as the development of the safety classification scheme and its relation to existing Department of Energy (DOE) and Nuclear Regulatory Commission (NRC) practices. Given next are detailed safety guidelines on the design of typical safety-related systems in high-hazard facilities at Rocky Flats Plant (RFP) and an implementation of the safety classification. The engineer or safety analyst interested in the implementation of the safety classification may wish to turn first to the Appendix, which resembles a "Q-list" in nuclear power plants, and in which the safety classification, quality, seismic, and redundancy requirements are given for the most common systems and equipment at RFP. This Appendix should be used as a basis for developing similar Q-lists for all high-hazard facilities at RFP. Improper use or misinterpretation of this guidance could result in unnecessary stringent system requirements that will lead to over-cost and over-design (e.g., complexity) of such systems or, conversely, in insufficient requirements resulting in a poor design of a system or facility, therefore jeopardizing safety. 85 refs., 2 figs., 6 tabs.

0550 Safeguards, Inspection, and Accountability

Refer also to citation(s) 6953

7043 (K/ITP–304) **Field measurements in support of enrichment measurement procedures development for type 30B UF_6 cylinders.** Mayer, R.L. II; Fields, L.W.; Cooley, J.N. Oak Ridge Gaseous Diffusion Plant, TN (USA). Nov 1989. 49p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. (ISPO–308). Order Number DE90003516. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Measurement procedures have been developed for use by the International Atomic Energy Agency (IAEA) in verifying the enrichment of low-enriched uranium hexafluoride in Type 30B cylinders using a portable multichannel analyzer coupled to a sodium iodide detector. Two field measurement campaigns were conducted to assess the capabilities of the measurement system and to provide information necessary to develop implementation procedures. Results indicate that the measurement system is capable of meeting IAEA Category FO measurement requirements provided appropriate corrections are made for differences in cylinder wall thickness. Modifications to the analyzer firmware and detection hardware are recommended to improve instrument performance and to simplify use of the equipment. The field tests are described, measurements results are reported, and system enhancements are identified. 6 refs., 10 figs., 2 tabs.

0560 Legislation and Regulations

Refer also to citation(s) 6952

07 ISOTOPE AND RADIATION SOURCE TECHNOLOGY

Refer also to citation(s) 8996

0702 Radiation Sources

7044 (INS-R-346) **Cook Strait cable leak investigation, March-June 1985.** Barry, B.J.; Fitzgerald, G.J.;. Department of Scientific and Industrial Research, Lower Hutt (New Zealand). Inst. of Nuclear Sciences. Sep 1985. 9p. Order Number DE90612435. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS.

An investigation was made to locate a gas leak in an under-sea electric power cable. Krypton-85 was used as the tracer. Despite problems with the investigation there was strong evidence to suggest that the leak was in the joint between the land and sea portions of the cable. (auths). 1 ref; 4 figs.

7045 (TRI-PP-89-41) **A 30 MeV H^- cyclotron for isotope production.** Milton, B.F. (British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility); Dawson, R.; Erdman, K.L.; Gyles, W.; Kleeven, W.J.; Laxdal, R.E.; Milinkovie, L.; Pearson, J.B.; Poirier, R.L.; Schmor, P.W.; Schneider, H.R.; Walker, Q.; Dutto, G. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. May 1989. 4p. (CONF-890560–5: 12. international conference on cyclotrons and their applications, Berlin (Germany, F.R.), 8-12 May 1989). Order Number DE90004277. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

Because of an expanding market for radioisotopes there is a need for a new generation of cyclotrons designed specifically for this purpose. TRIUMF is cooperating with a local industrial company in designing and constructing such a cyclotron. It will be a four sector H^- cyclotron, exploiting the newly developed high brightness multicusp ion source. This source with H^- current capability in excess of 5 mA makes feasible accelerated H^- beam intensities of up to 500 μA. Beam extraction is by stripping to H^+ in a thin graphite foil. Extraction of two high-intensity beams, with energy variable from 15 to 30 MeV, is planned. The use of an external ion source, provision of a good vacuum in the acceleration region, and the careful choice of materials for components in the median plane leads to a cyclotron that will have low activation and can be easily serviced in spite of the very high operating beam intensities. A design extension to 70 MeV using many of the design features of the 30 MeV cyclotron can be easily made. Such a machine with a good quality variable energy beam is a highly desirable source of protons for isotope production, injection into higher energy high intensity accelerators, and as an irradiation facility for ocular melanomas. Design of the 30 MeV cyclotron is well advanced and construction is in progress. 6 refs., 3 figs., 2 tabs.

0705 Health and Safety

Refer also to citation(s) 7587

08 HYDROGEN

Refer also to citation(s) 7741

0801 Production

Refer also to citation(s) 6697, 6713, 7114, 7145

7046 (LBL–27955) **Development and evaluation of a process to produce hydrogen from coal.** Colson, T.E.; Lynn, S. Lawrence Berkeley Lab., CA (USA). Aug 1989. 47p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC03-76SF00098. Order Number DE90003937. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This thesis is a study of a proposed process to produce hydrogen from coal via coal gasification and the water-gas shift (WGS) reaction. A novel aspect of the process is the use of the U.C. Berkeley Sulfur Recovery Process (UCBSRP) for removal of CO_2 and H_2S from the gasified coal (Neumann 1986 and Sciamanna 1986). The CO_2 is recovered as a purified product and the H_2S is recovered as elemental sulfur. 14 refs., 3 figs., 13 tabs.

0802 Storage, Transport, and Handling

Refer also to citation(s) 7628, 7629, 7630, 7631, 8112

7047 (BNL–43426) **Annual operating plan for fiscal year 1990 for chemical/hydrogen energy systems program.** Wegrzyn, J.; Mezzina, A. Brookhaven National Lab., Upton, NY (USA). Jun 1989. 20p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC02-76CH00016. Order Number DE90003964. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Since 1975, Brookhaven National Laboratory (BNL) has served the US Department of Energy (DOE) as Field Manager for The Chemical/Hydrogen Energy Systems (C/HES) subprogram. In this capacity, BNL has provided technical and management support in accordance with DOE policy and budgetary guidance, which has resulted in several programmatic transitions reflecting: revised perceptions of future conventional resources costs and availability; redefinition of R & D priorities; and changes in technical scope through budgetary constraints. These changes are best summarized as: the transfer of the programmatic management mission to solar/renewable derived hydrogen (SERI), the phase out of BNL's hydrogen facilities, and the strengthening of BNL's interest in advanced hydrogen storage concepts. Hydrogen storage, although not primary, still remains a major concern because problems of accommodating the temporal mismatches of renewable energy supply with load center demands remains as a technical barrier to implementing a comprehensive hydrogen program.

7048 (BNL–43427) **Modification-assisted cold storage (MACS) final report.** Schwarz, J.A. (Syracuse Univ., NY (USA)). Brookhaven National Lab., Upton, NY (USA); Syracuse Univ., NY (USA). Feb 1989. 13p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC02-76CH00016. Order Number DE90003963. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The general objective of this program has been to verify the feasibility of storing >4% hydrogen by weight on activated carbon such that it is suitable for either mobile or stationary storage applications. The specific objective is to establish design and performance characteristics of a storage vessel containing superactivated carbon in order to provide specifications for an optimal hydrogen storage system operating at refrigeration temperatures. 7 figs.

7049 (RISO-M–2608(app.1)) **Chemical energy storage based on metal hydrides: Appendix 1. Inspection of magnesium powders.** Vigeholm, B. Risoe National Lab., Roskilde (Denmark). Apr 1989. 86p. (In Danish). Contract EM-22632;Contract EM-22632-1;Contract EM-2263-306. Order Number DE90728134. Available from NTIS (US Sales Only), PC A05/MF A01.

EFP-80; EFP-81; EFP-83.

The first step in the investigation of the finely comminuted magnesium materials, that might be appropriate for hydrogen storage, was a visual inspection by optical and scanning electron microscopy. Representative micrographs of all investigated materials are given in this report at magnifications between 50 and 10 000 times. The data give an overview of the large variations in particle size and shape in addition to a subjective impression of the very large variation in particle size for the individual powders. (author) 2 tabs., 14 ills.

7050 (RISO-M–2608(app.2)) **Chemical energy storage based on metal hydrides: Appendix 2. Particle size, shape and size distribution.** Vigeholm, B. Risoe National Lab., Roskilde (Denmark). Apr 1989. 101p. (In Danish). Contract EM-22632;Contract EM-22632-1;Contract EM-2263-306. Order Number DE90728164. Available from NTIS (US Sales Only), PC A06/MF A01.

EFP-80; EFP-81; EFP-83. Cover subtitle: Partikelstoerrelser, -form og stoerrelsesfordeling.

This appendix gives a description and a overview of the methods used to characterize size, shape and size distribution of the magnesium powders. (author) 43 tabs., 89 ills.

7051 (VTT-SYMP–102, pp. 63-73) **Hydrogen for energy storage.** Schreiber, R. (Oesterreichischer Forschungszentrum Seibersdorf GmbH, Seibersdorf (Austria). Institut fuer Energie- und Anlagentechnik). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

Hydrogen, generated by non-fossil primary energy, is - from an ecological point of view - the absolute ideal form to store energy. The realization of the tremendous consequences of the pollution of the environment by fossil energy techniques and the inevitable following expensive repairing of the environment force energy management by hydrogen obviously closer to the sphere of economy. Traditional and progressive techniques of generation, storage and utilization of hydrogen for power and heat production are discussed. The different methods, installations and operating characteristics are compared economically; special attention is paid to ecological aspects.

0805 Health and Safety

Refer also to citation(s) 7046

7052 (DLR-FB–89-39) **On the dynamics of the combustion process of hydrogen-air- and hydrogen-methane-air mixtures.** Eichert, H. (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt e.V. (DLR), Stuttgart (Germany, F.R.). Inst. fuer Technische Thermodynamik). Technische Univ. Muenchen (Germany, F.R.). Fakultaet fuer Maschinenwesen; Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt e.V., Koeln (Germany, F.R.). 1989. 119p. (In German). Order Number DE90729020. Available from NTIS (US Sales Only), PC A06/MF A01.

The dynamic of the combustion process of hydrogen/air- and hydrogen/methane/air-mixtures in long tubes, the boundary conditions for the deflagration-to-detonation transition and the associated pressure signals have been investigated experimentally and numerically. To influence this combustion process and, in particular, to narrow down the range of possible detonations of hydrogen/air-mixtures, different inhibitors have been considered. For the numerical modelling, the one-dimensional Random-Choice-Method has been chosen and further developed. The numerical calculations have been compared to the experimental results. The potential and the limitations of this numerical method have been shown. (orig.) With 105 refs., 2 tabs., 74 figs.

0808 Properties and Composition

7053 (NAL-SP–9, pp. 15-19) **Numerical simulation of hydrogen-oxygen chemical reactions in annular combustion chamber.** Watanabe, Shizui (Tokyo Metropolitan College of Aeronautical Engineering (Japan)); Fujii, Shuji. National Aerospace Lab., Chofu, Tokyo (Japan). Dec 1988. (In Japanese). In *Special publication of National Aerospace Laboratory. Proceedings of the 6th NAL symposium on aircraft computational aerodynamics.* Order Number DE89910195. Available from NTIS (US Sales Only), PC A12/MF A01.

The simulation of combustion, containing the hydrogen-oxygen diffusion phenomenon in the axial symmetry laminar flow field, being studied, it was improved, so as to interpret the continuous flow inlet and outlet, and diffusion mutually among the chemical radicals, in this report, which started with the presentation of axial symmetry fluid dynamical equation. Then, because the temperature field was spatially very gradient in the flow field containing the combustion phenomenon, the specific heat of gas and different transfer factors were required to be treated as functions of temperature. The transfer factors of compound gas were calculated on basis of those as pure substance of each constituent chemical radical of compound gas. Then, calculation formulas to give both the viscosity and thermal conductivity coefficients were derived, with exhibiting an example of its numerical analysis, which was a simulation conducted as far as the ignition, by preparing a vessel containing compound gas of nitrogen and oxygen under 0.1MPa (pressure) by 300K (temperature) as an initial condition, and having hydrogen under 0.3MPa by 2000K flow therein. Upon that simulation, a velocity vector, temperature distribution, etc., in 13msec after the start of flowing, were shown in figure. 9 refs., 7 figs.

0809 Environmental Aspects

Refer also to citation(s) 7046

09 BIOMASS FUELS

7054 (VTT-SYMP–102, pp. 295-308) **Upgrading waste residues into useful products by biotechnology.** MooYoung, M. (University of Waterloo, Waterloo, Ontario (Canada). Industrial Biotechnology Centre); Scharer, J.M. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

On the assumption that waste is a misplaced resource, we have examined the techno-economics of bioconversion processes for upgrading several types of residue materials, which are normally regarded as wastes, into useful products. In particular, we have researched those types of residues which, if left unattended, usually pose environmental pollution potentials as biohazard, nuisance-odour or scenic problems. These illustrative examples are based on three generic bioconversion process scenarios: agricultural and forestry cellulosics (straws, manures, pulps) to fuel (CH_4, EtOH) and food (SCP) products; minerals from mine tailings (uranium, silver, gold, copper); desulphurization of low-grade oil and coal. In these scenarios, biological and bioreactor kinetics are explored in terms of retro-fits to create overall non-waste technologies.

0907 Resources

Refer also to citation(s) 7100, 7111

7055 (DOE/OR/21390–25) **Great Lakes Regional Biomass Energy Program: Final report, September 1, 1988–August 31, 1989.** Kuzel, F. Council of Great Lakes Governors, Chicago, IL (USA). Nov 1989. 59p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract FG05-83OR21390. Order Number DE90003845. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This is the annual report of the sixth year of operation of the Great Lakes Regional Biomass Energy Program. The program was initiated in 1983 with a grant to the Council of Great Lakes Governors from the Biofuels and Municipal Waste Technology Division of the US Department of Energy. Stressing near-term biomass feedstock production techniques and conversion processes, the objective of the program is to increase the use of biomass energy by the public and private sectors in the seven state Great Lakes region. States that are in the Great Lakes region include: Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio and Wisconsin. The Great Lakes Regional Biomass Energy Program is divided into three separate operational programs. The first is the State Grant Program, which provides resources to the seven state energy offices in the region to increase their capabilities in biomass energy. State-specific activities and interagency programs are emphasized in the State Grant Program. The second, the Subcontractor Program, involves the letting of subcontracts to private organizations to address regional biomass issues and needs. The third is the In-House Technology Transfer Program in which Council staff develop biomass energy publications and reports.

7056 (FDAL–P-362) **The competitive position of fuelwood from proposed energy plantations in Newfoundland.** Fletcher (D.) and Associates Ltd., Fulford Harbour, BC (Canada). Mar 1988. 47p. Contract DSS 01K24-7-0010-XAQ. (MICROLOG–89-04514). Available from PC Petawawa National Forestry Institute, Distribution Centre, P.O. Box 2000, Chalk River, ON, CAN K0J 1J0; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

The objective of this report is to assess the competitive position of biomass from proposed energy plantations in Newfoundland. The assessment is based on a usable energy approach talking into account the heat value and cost of each feedstock as well as the operating parameters, cost configurations and efficiency of the system recovering energy from the feedstock. Analysis is based on the direct combustion of fuelwood to produce steam. The following 3 energy feedstocks are examined in this report: biomass from hypothetical energy plantations in central Newfoundland, biomass from

non-commercial natural forests adjacent to the hypothetical plantations, and fuel oil. The estimates of the cost of steam generated from each feedstock are as follows: biomass from energy plantations, $6.63 per GJ; biomass from non-commercial forests, $6.60 per GJ; fuel oil (6), $7.68 per GJ. Consequently, the findings suggest that on the basis of current price and cost levels and the specific assumptions used in the analysis, energy plantation biomass could compete with the two major feedstocks used for the generation of steam in central Newfoundland. The cost of biomass from the hypothetical energy plantations could increase from $54/ODT (oven dry tonne) to $70/ODT and still remain competitive with fuel oil at the cost and price levels prefailing in mid-1987. Many positive social and economic benefits could accrue from the development of energy plantations in Newfoundland. However, plantations utilize a developing technology. Major risks and uncertainties are still present and only experience gained from large scale commercial operations over a period of time will fully identify their impact. 72 refs., 2 figs., 9 tabs.

0908 Production

Refer also to citation(s) 7085, 7086, 7087, 7088, 7089, 7090, 7093, 7094

7057 (DOE/ER/13290–5) **Selectivity of the reactions of oxygenates on transition metal surfaces: Progress report, December 15, 1988–December 14, 1989.** Barteau, M.A. Delaware Univ., Newark, DE (USA). [1989]. 6p. Sponsored by U.S. DOE Energy Research. DOE Contract FG02-84ER13290. Order Number DE90003911. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The goal of this research has been to understand, by means of surface science studies, the elementary processes involved in the synthesis of higher oxygenates on transition metals, and the dependence of these processes upon the nature of the surface. We have completed a considerable body of work (Ph.D. thesis of J. Lynn Davis, 1988) on the reactions of alcohols, aldehydes, and carboxylic acids on clean and oxygen-containing Pd(111) surfaces. Work during the past year has focused on the surface chemistry of rhodium. We find both interesting similarities and differences between rhodium and palladium. Comparison of the two sheds light on common reaction networks among the transition metals, and on the differences between them which permit control of selectivities in catalytic reactions.

7058 (ORNL/M–978) **Biotechnology in biomass crop production: The relationship of biomass production and plant genetic engineering.** Harry, D.E. (Illinois Univ., Urbana, IL (USA). Dept. of Forestry); Sederoff, R.R. Oak Ridge National Lab., TN (USA). Dec 1989. 47p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC05-84OR21400. Order Number DE90004412. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

There is great potential for the application of plant genetic engineering to production of biomass crops. Two factors largely determine the feasibility of crop improvement using genetic engineering: (1) the status of technology for the transfer and expression of foreign genetic material in plants, and (2) the level of understanding about genetic factors involved in the process or trait to be manipulated. Although information and technology for exploiting the potential of genetic engineering is in an early developmental phase, new research initiatives can now be taken to make significant advances. In this report we evaluate the nature and status of information and technology relating to specific problems of interest for production of biomass crops. In our discussions, we emphasize woody crops because our expertise is stronger in this area, but we have included information on herbaceous crops as appropriate. Plant genetic engineering has the potential to improve plantation or stand establishment, biomass production, and structural or chemical properties for efficient biomass utilization by either direct combustion or by conversion. Such research programs must be highly interdisciplinary, involving new technologies in laboratory research, in addition to traditional field testing. 119 refs.

7059 (SERI/SP–231-3521, pp. 1-16) **Ethanol from lignocellulose: The DOE (Department of Energy)/SERI (Solar Energy Research Institute) alcohol fuels program.** Goodman, B.J. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

Ethanol is a high octane liquid fuel that is compatible with today's transportation system. It can be produced by biological processes from lignocellulosic feedstocks. Biomass is an attractive feedstock for ethanol production because it is available in large quantities at low cost. The major advantage of biological processes is that they have the potential to convert biomass to liquid fuels with an efficiency approaching 100%. In order to achieve this, however, each fraction of the lignocellulosic feedstock must be processed separately. The Alcohol Fuels Research Program, which is managed by the Solar Energy Research Institute (SERI) for the US Department of Energy's Biofuels and Municipal Waste Technology Division, conducts a program of research and development with the goals of developing processes for converting lignocellulosic materials to ethanol and other fuels in an efficient and cost-effective manner, and facilitating the adoption of these processes by industry. This report summarizes the state of the art for this technology and the research conducted by the Alcohol Fuels Research Programs in the past year. Detailed descriptions of the individual research projects are included.

7060 (SERI/SP–231-3521 A.1-A.11) **Acid hydrolysis of cellulose in biomass to fermentation sugars.** Wyman, C.E. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

In this paper, an overview is presented of acid hydrolysis processes for breakdown of the cellulose in biomass into glucose sugars that can be fermented to ethanol. First, process descriptions are provided for six acid catalyzed processes: the plug flow reactor, the percolation reactor, the progressing batch reactor, the low temperature concentrated sulfuric acid process, liquid phase hydrochloric acid hydrolysis, and liquid phase hydrofluoric acid hydrolysis. The major cost components of each option are presented along with discussions of important cost considerations for each. The plug flow and progressing batch dilute acid hydrolysis processes were selected for engineering research at SERI (Solar Energy Research Institute), while the Tennessee Valley Authority (TVA) pursued the concentrated sulfuric acid hydrolysis process. Due to funding constraints, support of these projects has been terminated to focus on enzymatic hydrolysis options that promise higher yields at low cost.

7061 (SERI/SP–231-3521 B.1-B.12) **Enzymatic hydrolysis for liquid fuels production from renewable feedstocks.** Wyman, C.E. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

Production of liquid fuels such as ethanol from lignocellulosic feedstocks provides a stable, renewable source of premium transportation fuels that now must be imported into the United States at an ever increasing rate. Liquid fuels derived from renewable resources also don't contribute to the net accumulation of carbon dioxide in the atmosphere and global warming due to the greenhouse effect since carbon dioxide released when the fuel is burned is continually recaptured by biomass for perpetual recycle to liquid fuels. Enzymatic hydrolysis converts the cellulose in biomass into ethanol with extremely high selectivities, thereby maximizing fuel yields, a key to economic viability. The simultaneous saccharification and fermentation (SSF) process has been selected for focused development with the limited resources of the Biochemical Conversion Alcohol Fuels Program because the process has the potential to produce ethanol at prices competitive with existing liquid transportation fuels. Significant progress has been made in the last five years to lower the projected ethanol selling price from about $4.00/gallon to about $1.35/gallon, but further research is required on the principal steps in cellulose conversion (feedstock pretreatment, hydrolysis and fermentation, incorporation of actual feedstock, enzyme production, enzymology, and integrated scale testing) if the

Program is to meet its goal of producing cost effective liquid transportation fuels from renewable feedstocks.

7062 (SERI/SP–231-3521 B.137-B.146) **Cellulase recovery: Problems and potential.** Woodward, J. (Oak Ridge National Lab., TN (USA)); Lee, N.E. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. DOE Contract AC05-84OR21400. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

The enzymatic hydrolysis of cellulose may become commercially feasible if the enzyme is recovered and reused. The use of immobilized cellobiohydrolase (CBH) and endoglucanase (EG) does not appear feasible since the substrate itself is insoluble. Since the β-glucosidase (BG) component of cellulase acts upon soluble substrates it has the potential to be immobilized, used, and reused in this form. The problem of CBH and EG recovery has been tackled by examining their ability to be adsorbed to inorganically-based kieselguhr Macrosorb granules which can be used repeatedly for cellulase adsorption. The kinetics of the adsorption of Trichoderma reesei C30 cellulase protein to DEAE-Macrosorb are described and these Macrosorb particles have been used to recover cellulase from Avicel and steam-exploded aspen wood hydrolysates. The problem of β-glucosidase recovery could be achieved by immobilizing it onto an affinity material such as concanavalin A from which this enzyme is difficult to elute. Cellulase adsorbed onto lignocellulosic residues at the completion of hydrolysis can be eluted from the residue using a protein denaturant. Reactivation of the denatured enzyme may be possible.

7063 (SERI/SP–231-3521 B.147-B.161) **The thermal denaturation of Trichoderma reesei cellulases.** Baker, J.O.; Tatsumoto, K.; Grohmann, K.; Himmel, M.E.; Woodward, J.; Wichert, J.M. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

The thermal denaturations of four purified Trichoderma reesei cellulase components, CBHI, CBHII, EGI, and EGII, have been monitored using a combination of classical temperature/activity profiles, differential scanning microcalorimetry, and thermal-scanning fluorescence emission spectrometry. Strong correlations were found between the results of enzyme activity studies and the results obtained through the more direct physical approaches, in that both DSC and the activity studies showed EGII to be much more thermostable (by 10 to 11°C) than the other three enzymes, which were shown by both methods to be very similar in thermal stability. The temperature-dependence of the wavelength of maximum tryptophan emission showed a parallel result, with the three less thermostable enzymes grouped together in this regard, and EGII differing from the other three in maintaining a less-exposed tryptophan microenvironment at higher temperatures than in the case of the enzymes less resistant to thermal denaturation. DSC results suggested that at least two transitions are involved in the unfolding of each of the cellulase components, the first (lower-temperature) of which may be the one correlated with activity loss.

7064 (SERI/SP–231-3521 B.162-B.174) **Liquid fluidized bed starter culture of Trichoderma reesei for cellulase production.** Tengerdy, R.P. (Colorado State Univ., Fort Collins (USA)); Won Ho Rho; Mohagheghi, A. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

A starter culture of Trichoderma reesei (RUT-C30), prepared in a liquid fluidized bed reactor (LFBR) in a 36h operation, was superior to a conventional 7 day shake flask inoculum for cellulase production. Spores (1.0×10^8g carrier) were coated to 0.25 mm size corncob in a medium containing 1.0% corn cob, 0.5 g/l xylose, and 0.1 g/l lactose in a balanced salt solution. The particles were fluidized with an increasing velocity (0.1-0.25 cm/sec), commensurate with increasing biofilm thickness, to prevent the aggregation of particles, improve mass transfer through the thickening biofilm, and facilitate the transport of the loaded particles to the top of the reactor for easy separation. The LFBR starter, when used in a stirred tank reactor for cellulase production on 5% pure cellulase (solca fluc) medium, gave a cellulase activity of 6.5 IU/ml and a volumetric productivity of 64 IU/1, h in a 5 day fermentation, compared with a shake flask starter which gave 3.2 IU/min cellulase activity and 31 IU/1,h volumetric productivity. In comparison with T. harzanium mutants, T. reesei (Rut-C30) produced more cellulase but less beta-glucosidase.

7065 (SERI/SP–231-3521 B.175-B.183) **Optimization of cellulase productivity from acidothermus cellulolyticus.** Shiang, M. (Colorado State Univ., Fort Collins (USA)); Linden, J.C.; Mohagheghi, A.; Grohmann, K.; Himmel, M. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

Acidothermus cellulolyticum, a bacterial isolate from hot springs in Yellowstone National Park, produces cellulase enzymes when grown in cellobiose-containing medium. The objective of the overall study is to optimize cellulase productivity. The authors have reported herein results of the study achieved in batch culture, fed-batch culture and by of secondary cellulose substrates. Findings from this series of experiments are three-fold: (1) High cell density A. cellulolyticus fermentations are feasible using fed-batch cultures than batch culture both with glucose and cellobiose substrates. (2) Enzyme production is prohibited by use of glucose as an initial substrate; presumably catabolite repression of enzyme synthesis is operative. (3) Sustained cellulase enzyme production by the fed-batch culture is achieved by use of secondary cellulose substrates.

7066 (SERI/SP–231-3521 B.184-B.193) **Simultaneous saccharification and fermentation using whole culture broth verses filtrate as the cellulase enzyme source.** Schell, D.J.; Hinman, N.D.; Wyman, C.E. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

Cellulase, an enzyme that catalyzes the break down of cellulose into glucose, is produced inside fungal cells and secreted into the surrounding media. In commercial cellulase production, the cells are removed from the broth and the enzyme concentrated and sold. However, the cells contain significant amounts of β-glucosidase (one of the components of the cellulase enzyme complex), and this extra enzyme source could improve the performance of the simultaneous saccharification and fermentation (SSF) process for conversion of cellulosics into ethanol. To test the possible contribution of mycelia bound enzyme to SSF performance with modern enzyme preparations, the performance of SSF using whole culture broth (with cells) was compared to SSF performance using culture filtrate (without cells). Cellulase broth was produced using the Trichoderma reesei mutant L-27 obtained from Cetus Corporation. An assay was developed to measure effective activities of the whole cellulase broth verses the filtrate. Measurements of cellulase activities showed that the broth has more activity than the filtrate, but the ratio of activities changed during enzyme production. Subsequent SSF experiments were conducted at 37°C in shake flask with Saccharomyces cerevisiae and a mixed culture of S. cerevisiae and Brettanomyces clausenii at various enzyme loadings. Results showed that for the S. cerevisiae SSF at low enzyme loadings, the broth produced significantly higher ethanol yields than the cellulase filtrate, but broth did not improve SSF performance for the mixed yeast culture.

7067 (SERI/SP–231-3521 B.194) **The effects of process variables on cellulase adsorption for a simultaneous saccharification and fermentation system.** Schoenrock, J.F. (Texas Tech Univ., Lubbock (USA)); Tock, R.W.; Beck, S.R. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

The influence of ethanol, pH, and temperature on the equilibrium adsorption of Trichoderma cellulase on pure cellulose was investigated. The objective was to identify conditions of reduced adsorption so as to provide information valuable to the design of an enzyme recycle scheme. Freundlich adsorption isotherms were obtained by allowing a cellulase solution to reach adsorption equilibrium with various amounts of purified cellulose. Isotherms at different combinations of pH, ethanol, and temperature characterize the effect of these variables on cellulase adsorption. Baseline adsorption data were taken at 50 deg C, 8% ethanol, 6 millimolar glucose, and pH 5.0. This was used as starting point for a directional search to find conditions of minimum adsorption. Each variable was changed sequentially in order to observe the individual

variable effects. A pH shift from 5.0 to 7.0 produced no significant effect. Increases in temperature and ethanol concentration reduced adsorption. A minimum observed at 50 deg C and 16% ethanol (the highest values for these variables used). At these extremes however, considerable denaturation of the enzyme occurred. Statistical Analysis of data indicate that an interactive effect between temperature and ethanol concentration results in lower adsorption levels than expected from additive effects.

7068 (SERI/SP–231-3521 B.214-B.222) **Role of xylan in resistance of Aspen fiber cell walls to enzymatic hydrolysis.** Soltes, E.J. (Texas A and U Univ., College Station (USA)); Lin, S.C.K.; Kong, F. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

This research concerns mechanisms of plant cell wall resistance to attack by polysaccharide degrading enzymes, and more specifically a determination of the relative roles of structure and chemical composition of hemicellulose (xylan), acetate and lignin in the cellulose accessibility issue. The overall working hypothesis of this research effort is that hemicellulose chemistry, content and orientation have not been fully credited for the resistance of lignified tissues to enzymatic hydrolysis. Sugar yield is found to be enhanced by decreasing lignin content, high-moisture conditions before digestion, using smaller particle size in oxidation, grinding samples before digestion, and oven-drying before digestion. More data is being developed and results are being analyzed. Preliminary data suggest that acetate is highly responsible for shielding in enzyme hydrolysis of aspen wood, confirming results reported earlier (Grohmann 1989).

7069 (SERI/SP–231-3521 B.223-B.228) **Strategies toward characterization and enhancement of secretion by Trichoderma reesei.** Merivuori, H. (Lehigh Univ., Bethlehem, PA (USA)); Duck H. Suh; Sands, J.A. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

A new approach to development of enhanced secretion strains of Trichoderma reesei was investigated. Thirty eight (38) fatty acids and fatty acid derivatives were tested for their effects on the growth and protein secretion properties of this cellulolytic filamentous fungus. Two C10:0 compounds, decanoic acid and decanol, were the strongest inhibitors, completely inhibiting growth and production of secreted cellulases at 75 μg/ml. At 40 μg/ml of decanoic acid, growth-normalized protein secretion from hypersecretory strain RL-P37 was reduced approximately two-fold. Based on the rationale that the growth and secretion inhibitory effects of decanoic acid, decanol, and other previously studied membrane perturbers might provide useful selection conditions for isolation of new enhanced-secretion mutants of T. reesei, the authors screened mutagenized stocks for perturber-resistant mutants. No mutants resistant to the C10 acid or alcohol were isolated. A collection of mutant resistant to phenylethanol or cetyltrimethylammonium bromide was isolated and characterized. None of these mutants showed any significant increase in secretory capacity. Further significant enhancement of T. reesei as an enzyme producer will most likely come from detailed studies on the physiology of secretion in this fungus and by manipulation of cloned DNA for insertion back into Trichoderma using recently developed transformation protocols.

7070 (SERI/SP–231-3521 B.229-B.266) **Molecular biology of the CBHII cellulase enzyme.** Shoemaker, S. (Genencor, Inc., San Francisco, CA (USA)). Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

This report summarizes work toward identifying the amino acid residues in cellobiohydrolase II (CBHII) which are important to catalysis. CBHII represents approximately 15% of the total cellulase enzyme produced by most strains of T. reesei and it may be the best single enzyme for saccharifying cellulose. A hypothesis that the catalytically important amino acid residues are located at position 175 and 184 was tested. The authors used mutagenesis to impart these changes and used heterologous expression in Aspergillus to obtain altered forms of the enzyme. In addition, a second type of modification to CBHII structure was examined. This modification to CBHII structure generates a smaller molecule which contains the putative substrate binding site and catalytic site. The latter portion of CBHII (the carboxy terminal end) will be omitted by deleting the 3' end of the gene beginning at the start of the third intron.

7071 (SERI/SP–231-3521 B.33-B.42) **Evaluation of pretreated woody crops for the simultaneous saccharification and fermentation process.** Spindler, D.D.; Wyman, C.E.; Grohmann, K.; Torget, R.W. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

Four dilute acid pretreated woody crops, (Poplar maximowiczii x nigra NE388, P. trichocarpa x deltoides N11, P. tremuloids and Sweetgum Liquidambar styraciflua), were evaluated in the simultaneous saccharification and fermentation (SSF) process for ethanol production. The yeast Saccharomyces cerevisiae was used in the fermentations as a single culture and in mixed culture with β-glucosidase producing Brettanomyces clausenii. Genencor 150L cellulase enzyme was either employed alone or supplemented with β-glucosidase. All SSF's were run at 37°C for eight days along with a saccharification study at 45°C under similar enzyme loadings. The results indicate that the single culture of S. cerevisiae achieves the highest ethanol yields and rates of hydrolysis at the higher enzyme loadings, while the mixed culture shows improvement over S. cerevisiae for the lower enzyme loadings without β-glucosidase supplementation. The best overall rates and final yields were observed for Poplar maximowiczii x nigra NE388 and Sweetgum Liquidambar styraciflua followed by P. tremuloides and P. trichocarpa x deltoides N11. Although there are some differences in substrates responses to SSF, all of these pretreated woody crops performed well as substrates for ethanol production.

7072 (SERI/SP–231-3521 C.1-C.11) **Simultaneous fermentation and isomerization of xylose to ethanol.** Lastick, S.; Mohagheghi, A.; Tucker, M.P.; Grohmann, K. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

Ethanol was produced from xylose by converting the sugar to xylulose, using commercial xylose isomerases, and simultaneously fermenting the xylulose by 13 different strains of yeast by anaerobic fermentation. The process was optimized with the yeast strain Schizosaccaromyces pombe (Y-164). The data show that the simultaneous fermentation and isomerization of 6% xylose can produced final ethanol concentrations of 2.1% w/v within 2 days at temperatures as high as 39°C.

7073 (SERI/SP–231-3521 C.12-C.16) **Overproduction of xylose isomerase.** Spencer, C.T. (Virginia Polytechnic Institute and State Univ., Blacksburg (USA)); Potts, M.; Lastick, S. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

The Simultaneous Fermentation Isomerization of Xylose requires the immobilized enzyme xylose isomerase. The construction of a plasmid system for overproducing this enzyme in E. coli has been accomplished. The research described in this report focuses on optimizing the conditions for cell growth and enzyme yield. A design for computer monitored cell cultivation has been established. Two xylose overproducing strains, JC1553 and LE392, were grown in batch and fed-batch fashion to high cell densities. The levels of xylose isomerase activity was determined to be stable as strain JC1553 reached high densities. Reversion of the heat sensitive repressor is described. Speculations on increasing enzyme production and future research are included.

7074 (SERI/SP–231-3521 C.17-C.27) **Cloning of xylulokinase gene for improved xylose and xylulose fermentation.** Ho, N.W.Y. (Purdue Univ., West Lafayette, IN (USA)). Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

D-Xylose is a major constituent of hemicellulose of plant species. Hence, it is one of the most abundant sugar molecules, second only to glucose, present in renewable biomass. However, up to now, xylose has not been used as a feedstock for the production of fuels and chemicals. This may be partly due to the inability of most

yeasts including Saccharomyces cerevisiae to ferment xylose. Recently, it was found that xylose can be converted to xylulose in vitro by the enzyme, xylose isomerase, and that the latter sugar could be fermented by most yeasts including S. cerevisiae. Xylulokinase, the enzyme responsible for the conversion of xylulose to xylulose 5'-phosphate, is present in all yeasts and is reported to play a pivotal role in yeast xylose and xylulose metabolism. This project is designed to study the possible overproduction of xylulokinase in S. cerevisiae and Schizosaccharomyces pombe by recombinant DNA techniques and to investigate the effect of overproduction of such an enzyme on yeast xylulose fermentation. Prior to the initiation of this project, the authors have already succeeded in the cloning of the yeast xylulokinase gene in E. coli. During the past year, the authors first succeeded in the construction of a S. cerevisiae xylulokinase mutant by using the gene disruption techniques. With the use of this mutant as the host, they succeeded in the construction of several genetically engineered yeast strains containing the yeast xylulokinase gene cloned on different plasmids and fused to different promoters. Their preliminary results indicated that, with the cloning of the xylulokinase gene on a high copy number plasmid, yeast could be made to grow at least 50% faster on xylulose and to ferment xylulose to ethanol at least two and a half times faster than the parent yeast which did not contain the cloned xylulokinase gene.

7075 (SERI/SP–231-3521 C.32-C.39) **Xylose fermentation with yeast.** Beck, M.J. (Tennessee Valley Authority, Muscle Shoals, AL (USA)). Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

The cost of products ethanol from biomass can be diminished by increasing the yield and reducing the processing steps. This report shows the results of tests which have been applied to the Xylose fraction as a means to address yield increases and reduction in processing steps. The yield of ethanol from the xylose fraction of corn stover, derived by both concentrated and dilute acid hydrolysis processing, was improved. The improvement resulted from separation of the growth phase for Candida shehatae, where an enriched nitrogen source was used as supplementation, and the production phase, where a reduced nitrogen source was supplied. The effects of levels of calcium, magnesium, and potassium, typically found in acid hydrolyzates, on ethanol production from xylose and mixed xylose and glucose by C. shehatae, Pichia stipitis, and Pachysolen tannophilus were tested. Calcium was significant, in comparison to magnesium and potassium, in its ability to promote ethanol production. Calcium was found to stimulate the production of ethanol from P. tannophilus in sugar mixes when supplemented in addition to an adequate nutrient supply. The yield of ethanol from the hemicellulose fraction of hardwood using C. shehatae was 0.25 g ethanol/g sugar consumed. The yield was achieved at a dilution rate of 0.17 h^{-1}. Forty-one percent of the xylose and 50% of the glucose were consumed. Productivity was not directly related to cell population size, but to dilution rate.

7076 (SERI/SP–231-3521 C.40-C.46) **Identification and evaluation of SERI-NF1 fungus for ethanol production from xylose fermentation.** Antonopoulos, A.A. (Argonne National Lab., IL (USA)). Solar Energy Research Inst., Golden, CO (USA). Jun 1989. DOE Contract W-31-109-ENG-38. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

This work aimed at identifying the SERI-NF1 fungus isolated by Solar Energy Research Institute investigators, as well as evaluating the fungus as an ethanol producer from xylose fermentations. Microscopic and physiological observations led to the conclusion that the fungus is Paecilomyces varioti Bainier 1907. The fungus grows relatively fast in PDA plates, and its cultures release a light sweet aromatic odor. In liquid cultures the fungus forms round mycelial balls (1-12 mm in diameter). It showed to be thermophilic (grown well at 26-36°C) and thermotolerant (exposed for two hours to 60°C resumed its growth), and to prefer pH levels close to neutrality. Cultures of the fungus were tested (in 125 ml flasks) for fermenting xylose to ethanol. Its growth in the liquid cultures was slow and formed mycelial balls. The yield of ethanol production was low. The amount of fungal mass has to be more than a few mycelial balls per flask to get a reasonable yield of ethanol.

7077 (SERI/SP–231-3521 C.47-C.53) **Immobilization of xylose isomerase from Escherichia coli.** Means, G.E. (Ohio State Univ., Columbus (USA)). Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

Xylose isomerase (EC 5.3.1.5) from an over producing strain of E. coli and lyophilized cells of that over producing strain have been incorporated into cationic polymer beads to effect their immobilization and to stabilize their catalytic activities at low pH values. Beads, typically about 2 mm in diameter, containing either the soluble enzyme or the lyophilized cells in both chitosan and in chitosan-polyethyleneimine mixtures crosslinked by sodium polyphosphate and other polyanions have been prepared by procedures similar to those of Vorlop and Klein (Biotech. Lett. 3:9-14 (1981)) and evaluated for both their physical stability and their catalytic activities. Beads with high mechanical/physical stability/durability and 25 to 40% catalytic activity as compared to free enzyme or cells can be routinely prepared.

7078 (SERI/SP–231-3521 D.1-D.11) **Technical and economic analysis of lignin conversion to methyl aryl ethers.** Bergeron, P.W.; Hinman, N.D. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

The economical use of lignocellulosics for the production of liquid fuel depends on the efficient utilization of all the components in the feed material. Economic studies to date of the wood-to-ethanol process have assumed that the lignin fraction of woody biomass is burned for process fuel requirements. Alternatively, the lignin itself can be converted to methyl aryl ethers (MAE's), products with blending octane numbers and Reid vapor pressures that make them excellent candidates for use as octane enhancers in gasoline. The SERI (Solar Energy Research Institute) Engineering Research Section has completed a design and economic analysis effort which investigated several production scenarios for the conversion of lignin to methyl aryl ethers. The major conclusions from this study are as follows: (1) At high oil prices and with improvements beyond current laboratory results in product yields from the lignin hydrocracker and MAE synthesis reactors and with the recovery and recycle of the excess hydrogen in the product stream leaving the hydrocracker, it would be more economical to convert the lignin produced in a wood-to-ethanol plant to MAE's than to use it as boiler fuel for the ethanol plant. (2) The largest potential reduction in the cost of producing MAE may be obtained from research aimed at increasing the yield from the lignin hydrocracking reactor. When this yield is increased from 48%, as obtained in the laboratory, to 72%, which approximates the theoretical yield, the MAE selling price decreases by 22%. This, therefore, represents the research area with the highest potential payoff.

7079 (SERI/SP–231-3521 D.12-D.22) **Hydrodeoxygenation and dealkylation of a model lignin compound.** Cowley, S.W. (Colorado School of Mines, Golden (USA)); Erickson, D.A. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

Dealkylated phenols can be produced from lignin by depolymerization followed by deoxygenation and dealkylation. The dealkylated phenols can be converted to methyl phenyl ethers and used as a high octane blending stock for gasoline. To break apart lignin molecules it is necessary to use a catalyst which contains hydrogenation, hydrogenolysis, and dealkylation functions. Most of the research on the hydrotreating of feedstocks from alternative fuel sources has focused on catalysts commonly used for the processing of petroleum. Since most petroleum sources contain significant amounts of sulfur, these catalysts have a high tolerance to sulfur. Lignin-derived feedstocks, however, contain very little sulfur. To use these catalysts for the processing of lignins, sulfur must be added to the feed to maintain the active sulfide surface. For this study, assorted modified alumina supports have been prepared and impregnated with molybdenum and various noble metals. The molybdenum catalysts were sulfided before use. Products from the different catalysts were compared. The noble metal catalysts were found to be more active than the sulfided catalysts. Although the

Noble metals are sensitive to the presence of sulfur in the feedstock, this should not present a problem for the low sulfur lignin feedstocks. The development of a catalyst suitable for lignin processing will be summarized. Modified supports have been prepared and characterized using BET and XRD. The catalysts were tested in a bench scale plug flow reactor using 4-propylphenol as the model compound to represent lignin. The products were analyzed using GC and GC/MSD to determine the catalytic reactions which had occurred.

7080 (SERI/SP–231-3521 D.23-D.37) **Liquid fuels from lignins.** Johnson, D.K.; Chum, H.L.; Ratcliff, M.A.; Anzick, R.; Baldwin, R.M. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

The objective of this task is to develop a process for the conversion of lignins from biomass-to-ethanol processes, to a mixture of phenols and hydrocarbons. After conversion of the phenols to methyl aryl ethers this mixture may be used as a high octane fuel additive for gasoline or possibly ethanol. Catalyst development has been aimed at the formation of a product mixture with a boiling range similar to gasoline. A stirred autoclave has been used to study the hydrotreating of lignins on a bench-scale. An economic and technical analysis has indicated that improvements in the lignin hydrotreating element would have the greatest impact to the overall economics of the process. The study of catalysts with supports of varying acidity has found them to perform better than commercial catalysts for the hydrodealkylation and hydrocracking of a lignin model compound, 4-propyl guaiacol. The three best catalysts have been selected for synthesis on a larger scale for testing with lignins. A catalyst presulfiding procedure carried out in large batches sufficient for several experiments, in a separate reactor from the stirred autoclave, has been developed and tested. A study of the hydrotreating of phenolic solvents, particularly m-cresol, found that using moderate temperatures and residence times sufficient lignin depolymerization was achieved without solvent degradation to anthracenes taking place. Hydrotreating of lignin dissolved in m-cresol results in an initial sample of pasting oil that may be separated from the solvent and its degradation products by simple means.

7081 (SERI/SP–231-3521 D.38-D.66) **Biomass characterization - A summary progress report.** Chum, H.L.; Johnson, D.K.; Black, S. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

The objective of this task is the chemical characterization of biomass substrates for alcohol conversion including lignins. This report summarizes selected work carried out in collaboration with several researchers. The areas addressed are: (1) Investigation of the molecular weight distributions of lignins comparing three different techniques: conventional gel permeation chromatography, universal calibration, and sedimentation equilibrium, performed in collaboration with Drs. M. Himmel, K. Tatsumoto, K. Oh, and K. Grohmann of the Biotechnology Research Branch; the continuation of lignin model compound studies and effects of solvents on high performance size exclusion of lignins, in collaboration with Dr. J. Hyatt from Eastman Chemicals Division. (2) Quantitative structural information on aspen lignins produced in Organosolv pretreatment in collaboration with Professor K. V. Sarkanen (University of Washington) and with Dr. D. Robert from the Centre d'Etudes Nuclaires de Grenoble. (3) Lignin degradative analyses to provide additional information on carbon-carbon bonding of acid-hydrolyzed lignins, in collaboration with Drs. Vincent Chiang and M. Funaoka (Michigan Technological University). (4) Solid state carbon-13 nuclear magnetic resonance cross-polarization/magic angle spinning (CP/MAS) for the characterization of pretreated biomass samples and assessment of crystallinity changes as a function of pretreatment conditions, in collaboration with Dr. J. Frye of the Colorado State Regional NMR Center. (5) Multivariate analyses and canonical correlations for the generation of chemically sensible correlations for lignin, carbohydrate, and biomass analyses in general. These studies are being performed in collaboration with Drs. R. Evans (SERI) and W. Windig (Eastman Kodak).

0909 Processing

Refer also to citation(s) 7060, 7061, 7062, 7063, 7067, 7079, 7080

7082 (EUR–12092) **Wood roasting demonstration unit: Demonstration project: Final report.** Dreyer, J.L. (Dreyer (J.-L.), Bretenoux (France)). Commission of the European Communities, Luxembourg (Luxembourg). Directorate General Telecommunications, Information Industries and Innovation. c 1989. 84p. (In French, English). Sponsored by Commission of the European Communities. BM/333/84-FR. Available from NTIS (US Sales Only), PC A04/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg; Price: ECU 7,50.

The report relates the implementation of a wood roasting demonstration unit with a nominal capacity of 15,000 T/year. Roasted wood is an intermediary product between raw wood and charcoal. Compared to the latter, it shows the advantage of being less crumbly and dirty, it lights easily and does not take moisture back. Roasted wood may be used as a reducing agent in electrometallurgy or as a fuel, notably for barbecuing and for cooking in the developing countries. The process used is a low temperature (about 280°C) pyrolysis of wood chips in a vessel with heat transfer by conduction. The demonstration project has proved the technical reliability of the process and has led to a precision of the economic viability limits. 5 figs., 4 tabs.

7083 (FSJ–8901, pp. 116-118) **Catalytic gasification of wood charcoal by H_2-H_2O mixtures.** Kuwahara, Eiichi (Kitami Inst. of Tech., Hokkaido, Japan); Suzuki, Tsutomu; Yamada, Tetsuo; Honma, Tsuneyuki. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

The possibility of synthetic gas manufacturing was studied by wood charcoal obtained by dry distillation with Ni catalyst and H_2-H_2O mixtures as the fundamental reseaerch to develop a fluid energy and process from wood. The influence of Ni addition and steam partial pressure (pH_2O) on the gasificating rate and gas composition was studied by using H_2-H_2O mixture as gasification material. Decarbonization rate decreased and carbon yield increased with the increase of Ni addition. This may mainly be caused by the fact that liquid components are acceleratively condensated and polymerized in the solid. Along with the increase of Ni addition, the gasificating activity at low temperature increased and the high active reaction caused by higher dispersion of Ni particles increased remarkably. It was found from the study as to the effect of pH_2O on gas composition produced that increase of pH_2O did not increase gasification rate remarkably but decreased the ratio of CH_4 of produced gas and increased the CO_2 amount. 3 refs., 4 figs., 1 tab.

7084 (ORNL/Sub–88-SC011/1) **Improved conversion of herbaceous biomass to biofuels: Potential for modification of key plant characteristics: Final report on a literature review and survey.** Sladden, S.E. (Auburn Univ., AL (USA). Dept. of Agronomy and Soils); Bransby, D.I. Oak Ridge National Lab., TN (USA); Auburn Univ., AL (USA). Dept. of Agronomy and Soils. Oct 1989. 74p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC05-84OR21400. Order Number DE90004416. Available from NTIS, PC A05/MF A01 - OSTI; GPO Dep.

Biomass crops are converted to fuels via biochemical and thermochemical processes. The process preferred depends on properties and cost of available feedstocks, and on the specific products desired. Since most mature biomass crops are composed of up to 80% cell wall fibers, the properties of these fibers determine, to a large degree, the conversion potential of the crop. However, biomass crops also contain small amounts of proteins, soluble carbohydrates and interfering materials (e.g., tannins and silica) which also influence the desirability of the feedstock in specific conversion processes. Fortunately, wide variation exists in the chemical composition of potential biomass crops. Although the chemical composition of feedstocks can be influenced significantly with judicious management has species selection, some traits are sufficiently heritable to permit breeding for improved feedstock composition. In addition to breeding for specific compositional traits directly, selection for in vitro digestibility or for easily-measured canopy or physiological traits may lead to more rapid and efficient

progress in feedstock improvement, provided those measurements are highly-correlated with desirable feedstock composition. At the same time breeders must improve, or at least avoid damaging, stand longevity, tendency of plants to lodge, and establishment traits (e.g., disease resistance and seedling vigor). 46 refs., 8 tabs.

7085 (SERI/SP–231-3521 A.12-A.23) **The progressing batch reactor.** Bergeron, P. (Solar Energy Research Institute, Golden, CO (USA)); Werdene, P. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

A series of pilot plant experiments have been conducted to compare the performance of a system utilizing two percolation reactors in series to a single reactor system. Although theoretically capable of producing higher glucose yields or concentrations, the two-reactor system concentrations were approximately the same and the yields considerably lower than those from the single reactor study. An associated kinetics study found the glucose degradation kinetics to be accelerated by chromium ions, but this effect was greatly reduced in the presence of wood. The presence of metal surfaces also increased the rate of degradation even without large ion concentrations. The poor performance of the reactor system is proposed to be caused by intraparticle glucose diffusion effects and the catalytic effect on glucose degradation reactors of chromium ions from the corrosion of stainless steel by the acid. Strategies for reducing the effects of these phenomena on PBR performance are presented.

7086 (SERI/SP–231-3521 A.24-A.34) **Hydrodynamic studies of hydrolysis reactors.** Calo, J.M. (Brown Univ., Providence, RI (USA)); Hradil, G. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

This paper is concerned with the investigation and characterization of the hydrodynamics of two different types of reactors that either have, or are currently being considered for application to the hydrolysis of wood chips: a packed bed, percolation reactor (SERI PB, for acid hydrolysis), and a liquid fluidized bed reactor (LFBR, for enzymatic hydrolysis). At the inception of this project, as reported at last year's Biochemical Conversion Program Annual Review Meeting (Calo and Hradil, 1987), their efforts were focused on the percolation reactor. However, due to changes in programmatic emphasis at SERI, this year they have phased out the packed bed reactor work in favor of an investigation of the hydrodynamics of LFBRs and derivative reactor types which seem to offer some significant advantages for enzymatic hydrolysis processes. Therefore, here they summarize their work on the percolation reactor, and introduce the new phase of the program on the LFBR. More specifically, in the current paper they report on: instaliation and testing of the SERI PBR reactor; development of a two-station tracer technique in a small-scale, glass column apparatus, constructed for this purpose; the development and some results from a dynamic numerical model of glucose behavior in a wood chip-fluid reaction system; design and construction of the LFBR apparatus, and the results of preliminary fluidization studies.

7087 (SERI/SP–231-3521 A.35-A.44) **Ethanol from cellulosic residues and crops.** Bulls, M.R.M. (Tennessee Valley Authority, Muscle Shoals, AL (USA)); Barrier, J.W. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

Technology for the conversion of cellulosic material to ethanol is being developed by the Tennessee Valley Authority in Muscle Shoals, Alabama. A low temperature, low pressure, concentrated sulfuric acid hydrolysis process has been defined in laboratory and bench and pilot scale studies conducted since 1983. Evaluations of the process using corn stover have resulted in conversion efficiencies of hemicellulose and cellulose to ethanol in excess of 90%. Process optimization studies are currently being conducted in the areas of acid hydrolysis, acid recovery, fermentation, and waste utilization. A skid-mounted concentrated acid hydrolysis demonstration unit has been designed, and equipment is being procured for its construction. The unit, capable of processing 30 lb/h, will allow on site testing of various feed stocks. It will also be used to produce hydrolyzate for fermentation and waste treatment studies. The economics of the concentrated acid hydrolysis process have been examined for a base case design. Ethanol production costs are estimated to be $1.78/gal. Research results indicate the potential to reduce the cost by as much as 95 cents/gal.

7088 (SERI/SP–231-3521 B.107-B.112) **Cloning the β-glucosidase gene.** Lastick, S.; Mohagheghi, A.; Tucker, M.P.; Grohmann, K. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

The enzyme β-glucosidase catalyzes the hydrolysis of the disaccharide cellobiose, producing glucose. The enzyme is important to the simultaneous enzymatic saccharification and fermentation of cellulosic biomass waste to alcohol (SSF) because other enzymes, the cellulases, that are used in this process are strongly inhibited by cellobiose. Fungal preparations of the cellulases generally have low and variable concentrations of β-glucosidase. In addition, the other enzymes bind to cellulose and can thereby be recovered from the SSF fermentations for reuse whereas the β-glucosidase cannot. There are several yeast and bacterial strains that ferment cellobiose because they contain β-glucosidase, but industrial yeasts, e.g. Saccharomyces cerevisiae or Schizosaccharomyces pombe, do not contain the enzyme. In this project, genes that code for β-glucosidase, isolated from different sources, are being cloned into bacterial cells for overproduction of the enzyme and into the industrial yeast strains to allow for efficient conversion of cellobiose to ethanol.

7089 (SERI/SP–231-3521 B.113-B.126) **Enzymology research.** Himmel, M.E.; Grohmann, K. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

Enzymology research at SERI in FY 1987-88 has focused on the problem of enhancing the effective lifetime of the key fungal cellulase enzymes under process conditions (i.e., those of SSF or SHF), since the cost of producing these enzymes has been identified as a sensitive issue in the overall bioconversion economics. The effective incorporation of cellulase enzyme hydrolysis in these process schemes requires the utilization of enzymes that demonstrate high solution stability as well as a scheme for recovery of this activity before disposal of spent feedstock. In this document they report the results of studies which were designed to quantitatively describe the heat-induced denaturation process of the four key enzymes of the Trichoderma reesei cellulase system, namely CBHI, CBHII, EGI, and EGII. From this knowledge they anticipate that weak links in the system can be predicted and improved upon by genetic or other means. In FY 1988 they also investigated possible improvements on the glutaraldehyde/β-glucosidase crosslinking scheme reported preliminarily in FY 1987. These improvements are based on the sequential crosslinking of the enzyme with glutaraldehyde- and p-azidophenylglyoxal (APG). The authors have also included in this report the results of early progress in the production of β-glucosiase homo-conjugates and β-glucosidase/CBHII hetero-conjugates through glutaraldehyde crosslinking.

7090 (SERI/SP–231-3521 B.127-B.136) **Visualization and stoichiometry of the active-enzyme cellulase complex from Trichoderma reesei.** Ellis, R.P. (Colorado State Univ., Fort Collins (USA)). Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

Monoclonal antibodies (MoAb) specific for unique antigenic epitopes on CBHI, EGI, and EGII have been produced. The production of MoAb specific for CBHII is in progress. Monoclonal antibodies specific for epitopes shared by EGII and CBHI as well as MoAb which reacts with an epitope on EGI, EGII, CBHI, and CBHII have been produced. Initial affinity purification of EGI has been attempted.

7091 (SERI/SP–231-3521 B.195-B.213) **Organosolv pretreatment.** Black, S.K.; Johnson, D.K.; Chum, H.L. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

The objective of this task is to explore Organosolv pretreatment as an option for fractionation of all biomass components for their

conversion into liquid fuels. Conditions optimal for pulp production differ substantially from those needed to produce cellulosic materials digestible by enzymes for glucose and subsequent ethanol production. This report addresses the following areas: (1) Evaluation of acid catalysts for Organosolv pretreatment and the use of a combined severity parameter such that important variables such as time, temperature, and catalyst concentration can be interpreted together as a single variable for a variety of different catalysts; (2) evaluation of sulfur dioxide as catalyst for Organosolv pretreatment and the comparison between sulfur dioxide and other acidic catalysts; (3) comparison between Organosolv pretreatments and dilute aqueous acid hydrolysis and the use of severity parameters for both types of pretreatments; (4) comparison of Organosolv and dilute acid hydrolysis with steam aqueous pretreatments. (5) the ability to predict compensating adjustments of cooking times, temperature profiles, and catalyst concentration to produce a cellulosic residue with appropriate xylan and lignin removal such that the residue easily undergoes enzymatic hydrolysis.

7092 (SERI/SP–231-3521 B.43-B.52) **Effect of acid diffusion on pretreatment/hydrolysis of Aspen hemicellulose.** Tillman, L.M. (Auburn Univ., AL (USA)); Lee, Y.Y.; Torget, R. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

Acid diffusivities for Aspen wood were experimentally determined for both the longitudinal and radial/tangential directions and for temperatures of 25, 50, and 70°C. This was accomplished via a dynamic method which correlated conductivity to acid concentration. Anisotropy due to grain orientation was quantified for each of three diffusional temperatures and was seen to decrease as diffusional temperature was increased. Arrhenius plots were constructed from diffusivity/temperature data with activation energies and frequency factors subsequently determined. The resulting Arrhenius equations allow interpolation and/or extrapolation of acid diffusivities within reasonable limits of pretreatment temperature range. The experimental Arrhenius constants were in close agreement to complimentary studies found in the literature.

7093 (SERI/SP–231-3521 B.53-B.66) **Mechanisms of plant cell wall resistance to polysaccharide degrading enzymes: A study using nuclear magnetic resonance analysis.** Mitchell, D.J.; Grohmann, K.; Himmel, M.E.; Schroeder, H.A.; Murphy, V.; Dale, B.E. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

This research project is directed toward identifying the key features and mechanisms of resistance to enzymatic hydrolysis of polysaccharides in hardwoods and agricultural residues (respectively, aspen wood and wheat straw). Selective mild treatments will be analyzed for their effects on chemical constituents of the plants cell wall using solid state carbon 13 nuclear magnetic resonance (NMR) analysis combined with cross polarization and magic angle spinning, (Called SS ^{13}c NMR CP/MAS). These treatments will be intended to selectively remove lignin, xylan, or acetyl groups in an attempt to identify their role in the overall resistance to cellulolytic enzymes. The work completed to date has dealt with the role of acetylation of the hemicellulosic xylan fraction on the resistance to enzymatic digestion. The results of this work show the importance of the degree of acetylation on the resistance to digestion of biomass. The first set of experiments directly show that as the degree of acetylation of isolated, reacetylated xylans increases, the resistance to enzymatic digestion increases abruptly at a value near the native degree of substitution of these biomass samples. Furthermore, the in vitro deactylation of the biomass samples was completed to various degrees using aqueous hydroxylamine solutions. Treatments with hydroxylamine resulted in the deacetylation of the biomass of values up to 90%, with minimal other modifications. The digestibility of both the xylan and cellulose fractions increased proportionally with increased deacetylation, up to a degree of deacetylation of 75% where other resistance became limiting.

7094 (SERI/SP–231-3521 B.67-B.92) **Adsorption of cellulase from Trichoderma reesei on cellulose and lignin of wood pretreated by dilute sulfuric acid with explosive decompression.** Hiroshi Ooshima (Dartmouth College, Hanover, NH (USA)); Burns, D.S.; Converse, A.O. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

The adsorption of cellulase on cellulose and lignin were examined by using cellulase from Trichoderma reesei, hardwood pretreated by dilute sulfuric acid under high pressure, and lignin prepared by a complete enzymatic hydrolysis of the pretreated wood. A significant amount of cellulase was found to adsorb on lignin during the hydrolysis of the pretreated wood. Hence the adsorption of enzyme on lignin as well as cellulose must be taken into account in the development of the hydrolysis kinetics. The adsorption of enzyme on cellulose and on lignin could be represented by Langmuir type isotherms. The data showed that the pretreatment at a higher temperature results in more enzyme adsorption on the cellulose and less on the lignin. The relationship between the hydrolysis rate and the amount of enzyme adsorbed is discussed.

7095 (SERI/SP–231-3521 B.93-B.106) **The role of agitation in promoting the enzymatic hydrolysis of cellulose.** Murphy, V.G. (Colorado State Univ., Fort Collins (USA)); Elander, R.T.; Wyman, C.E.; Wright, J.D. Solar Energy Research Inst., Golden, CO (USA). Jun 1989. In *Ethanol from biomass. FY 1988, annual report.* Order Number DE89009460. Available from NTIS, PC A20/MF A01.

The effect of agitation on the enzymatic hydrolysis of cellulose was studied in a 5.0 L stirred tank using a 5.0% (w/v) slurry of purified cellulose and an enzyme/substrate ratio of 20 IU/g. In experiments with a turbine impeller, maximum conversion of cellulose coincided with the agitation rate (65 rpm) required to completely suspend the particles. In experiment with an anchor impeller, complete suspension occurred at 25 rpm and maximum conversion at 40 rpm. With both impellers, the most efficient use of energy occurred at agitation rates below those needed for uniform suspension of solids. Comparing the most efficient cases, the anchor impeller consumed only one tenth the energy required by the turbine for the same level of conversion. A simple model of the hydrolysis process was derived. It incorporated the concepts of Langmuir adsorption of cellulase enzymes, product inhibition of enzyme activity and solid-liquid mass transport of products. This model was able to qualitatively predict the relationship between agitator power input and the rate of hydrolysis. It was concluded that agitation promotes the rate of hydrolysis by enhancing the mass transfer of (enzyme-inhibiting) sugar products away from reaction sites on the solid surface.

7096 (STU–87-530) **Cyclone gasifier - modelling.** Warnqvist, B. (AaF-IPK AB, Stockholm (SE)). Swedish National Board for Technical Development, Stockholm (Sweden). 31 Jan 1989. 34p. (In Swedish). Project STU-742-87-530. Order Number DE90728275. Available from NTIS (US Sales Only), PC A03/MF A01.

A study was performed of gasification of wood in a cyclone gasifier and direct combustion of the product gas in a connected boiler. The modelling was made using the computer code FLUENT in order to compare to fuel oil combustion in a 50MW boiler. The result was, as expected, that gasification could not obtain the same thermal power as oil combustion. The gasifier has however a good potential, representing an 30% lower investment than conventional gasifiers.

7097 (VTT-SYMP–102, pp. 127-144) **Liquid fuels from biomass: a technoeconomic assessment.** Bridgwater, A.V. (Aston University, Birmingham (UK). Chemical Engineering Department); Double, J.M. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

A technical and economic study of the conversion of renewable feedstocks to liquid fuels has been initiated. The main objective of the project is to identify and evaluate all alternative technologies for liquid fuel production from biomass and solid wastes in order to identify the more promising technologies and RandD needs as a strategic planning aid to the European Community. The methodology adopted is to construct a robust techno-economic computer simulation of the whole range of thermochemical, biochemical and physical conversion processes. Each of the processes is divided into Process steps' each process step being defined as a self-contained processing operation. A model is being constructed of each process step, calculating the material balance, energy balance

and capital cost of the step. Whole processes will then be constructed from the individual step models and the economics of each process evaluated. Some process steps are well established and commercially available, such as methanol synthesis, and state-of-the-art technology will be used in the model. Others steps, however, are still at the research or development stage, such as pyrolysis liquid upgrading. These unproven steps will be compared and evaluated to identify the more technically and economically promising alternatives. This will aid identification of further RandD needs. The scope, methodology and some early results are presented.

7098 **Opportunities for improved energy recovery in pulp mills.** Compere, A.L. (Oak Ridge National Lab., Oak Ridge, TN (US)); Griffith, W.L.; Joyce, T.W. vp of The 8th Miami international conference on alternative energy sources. Volume 1-2 (Condensed Papers). Vezioglu, T.N. Clean Energy Research Inst. University of Miami, Coral Gables, FL (1988). (CONF-871204–: 8. Miami international conference on alternative energy sources, Miami Beach, FL (USA), 14-16 Dec 1987).

The major U.S. biomass industry is the pulp and paper industry, which currently manages around 6% of all U.S. land and consumes annually 3 to 4 quads of energy. As opposed to the present solar-biomass technologies which require development of an infrastructure for production and collection of materials, technologies based on pulp and paper low-valued and recycle streams are already a part of a well-managed renewable resource technology whose infrastructure has been developing for more than a century. This study compares the energy balance and economics involved in using pulp streams as feedstocks for industrial solvent fermentations to conventional petroleum-based technologies. Both petroleum industry in-house energy balances and DOE energy balance studies are used to estimate process and energy costa for the production of industrial ketones and alcohols. ASPEN (Advanced System for Process ENgineering) computer calculations are used to estimate mass and energy balances for fermentation streams sized to reflect present pulp and paper streams.

0910 Properties and Composition

Refer also to citation(s) 7081

7099 (VTT-SYMP–102, pp. 35-88) **Adaption, yield and quality of sorghuvm as a renewable source of biomass.** McBee, G.G. (Texas AandM University, Texas (USA). Soil and Crop Sciences Department); Miller, F.R. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

Sorghum (Sorghum bicolor (L.) Moench) is the fifth leading cereal crop in the world. It is produced on approximately 44.1 million hectares, annually in seven major geographic areas. A spectrum of genotypes for high dry matter yield has been developed at Texas AandM University and classified as forage or sweet, high energy and ᵇiomass· The production system resulting in the highest annual yields has included a ratoon harvest procedure with 31.238 kg ha^{1} of dry biomass. Quality determinations have shown the biomass, exlusive of panicle, to contain near 80% carbohydrates partitioned between structural (SC) and nonstructural (NSC) forms. Items primarily affecting quality have been genotype, maturity, material handling, spacing, and various cultural factors. Total volatile solid content of all types has exceeded 92%. Methanogenesis studies have shown that over 70% of the volatile solid (V.S.) may be reduced by anaerobic fermentation. Methane yields approaching 6.0 cubic feet per pound of V.S. at standard temperature and pressure have been obtained.

0920 Combustion

7100 (VTT-SYMP–102, pp. 103-126) **Pollution alleviation in wood combustion - pretreatments.** Ramohalli, K.N.R. (University of Arizona, Tucson (Arizona). Departament of Aerospace and Mechanical Engineering); Miller, C.A.; Palmer, J.S. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

The concept of simple, inexpensive pretreatment for low-pollution combustion of woody biomass is explored in a multi-phase program. Based on the belief that a good theoretical understanding of the fundamentals is necessary for an economical program, the micro-details of wood pyrolysis are investigated. The fibrous heterogeneity and the nonlinear Arrhehius degradation term are explicily included. Analytical solutions are obtained through the method of matched assymptotic expansions; only final solutions are quoted in this paper. Guided by the theory, small samples are burned in a furnace. The samples are instrumented with fine bead μ thermocouples. Morphological structural changes are carefully observed through scanning electron microscopy. A 0.5% solution of calcium acetate is used to pretreat the wood, and the experiments are repeated. Time to ignition and the temperature profiles are obtained. The difference in the char, ash, and residue are noted and compared with the pretreatment case. The differences seem to indicate bright promise for the promotion of widespread use of woody biomass as an energy source.

0930 Economic, Industrial, and Business Aspects

Refer also to citation(s) 7055, 7096

7101 (NA–P-363) **Forest biomass energy use in Newfoundland.** Northland Associates Ltd., St. John's, NF (Canada). 1988. 93p. Contract DSS XAQ87-00062-(021). (MICROLOG–89-04515). Available from PC Petawawa National Forestry Institute, Distribution Centre, P.O. Box 2000, Chalk River, ON, CAN K0J 1J0; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

The purpose of this report is to provide an update of the information pertaining to the present status of the biomass industry in the province of Newfoundland. The history of forest biomass utilization in the province is reviewed. Despite oil price volatility, biomass continues as a source of fuel and, since the last decade several programs have proved successful in expanding the biomass fuel burning capacity of the province. Biomass consumptions within the various sectors of the economy are reviewed as is the economic perspective for this form of energy. The yearly consumption of biomass in Newfoundland is 590,000 green tonnes, that is, 5.7% of the total energy consumed or 8.9% of the oil energy consumed; the overage cost of round wood and wood chips is $30/tonne, that of bark is unknown, and that of wood fuel from other sources is $17/tonne. Areas for future consideration and possible application of this form of energy are outlined. Wood supply, and the cost of competitive fuel types, are the key considerations for any prospective energy conversion project; other areas of potential constraint are the environment, technology, and government policy. This report has required a review of the available literature as well as interviews with numerous groups and individuals throughout the province. In conclusion, the development of a local forest biomass industry offers a very significant benefit in terms of revenue retained and recirculated within Newfoundland. 56 refs., 3 figs., 14 tabs.

7102 (VTT-SYMP–102, pp. 33) **Systems analysis in forest sector management.** Kallio, M. (Helsinki School of Economics (Finland)). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

Abstract only. FORESTS/global analysis; FORESTS/systems analysis; FORESTS; WOOD; TREES; WOOD PRODUCTS INDUSTRY; GLOBAL ASPECTS; ECONOMICS; WOOD FUELS

0950 Environmental Aspects

Refer also to citation(s) 8406

0990 Products and By-Products

7103 High temperature lubricants from biodeuterated materials produced by algae. Neihof, R.A. (Naval Research Laboratory, Washington, DC (USA)); Ross, M.M.; Munro, R.G.; Hsu, L.S.; Ku, C.S. *American Chemical Society, Division of Petroleum Chemistry, Preprints (USA)*, 32(3): 865-870 (Aug 1987). (CONF-8708315--: American Chemical Society Division of Petroleum Chemistry, New Orleans, LA (USA), 30 Aug - 4 sep 1987).

The lubrication of materials at elevated temperatures is one of the primary barriers to the successful development of advanced heat engines. Such engines are being designed to operate at higher temperatures to attain higher efficiencies. In the near future, designs requiring liquid lubricants capable of sustained operation at temperatures in the range 300°C to 500°C can be expected. Such lubricants may also have applications in bearing systems where the objective is longer service life rather than higher operating temperatures. In both applications, oxidation reactions limit the capabilities of the lubricant. Consequently, producing a greater stability against oxidative degradation is one of the primary goals of lubrication research. The present paper investigates the potential for producing a lubricating basestock in which the oxidative stability has been improved by means of the process of deuteration. An alternative to the conventional chemical synthesis of deuterated materials is to employ microorganisms adapted to growth in pure deuterium oxide (D_2O). Possible advantages are lower costs, greater ease of production, and assurance of complete deuteration compared to conventional hydrogen-deuterium exchange reactions employing high temperatures, prolonged reaction times, and proprietary catalysts. The biosynthetic approach may also make possible the synthesis of deuterated compounds too labile for chemical synthetic methods. In this investigation algal species and growth conditions in 100% D_2O were sought which would result in large amounts of fatty acids suitable for synthesis of deuterated lubricants. Possible routes of synthesis of deuterated tetrahexanoate esters of pentaerythritol were explored. Tests for high temperature resistance to oxidation, friction and ware were made on the deuterated product made from algal lipids and compared with results on the hydrogen analog.

10 SYNTHETIC FUELS

1002 Production

Refer also to citation(s) 6500

7104 (DOE/PC/79935-12) **Circulation in gas-slurry column reactors: Seventh quarterly report, quarter ending June 30, 1989.** Clark, N.; Kuhlman, J.; Celik, I. West Virginia Univ., Morgantown, WV (USA). Dept. of Mechanical and Aerospace Engineering. [1989]. 66p. Sponsored by U.S. DOE Fossil Energy. DOE Contract FG22-87PC79935. Order Number DE90004019. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

During this quarter progress has been made in all 3 areas of the bubble column research (probe measurements, laser doppler anemometry and numerical modeling of the two phase flow). In particular, bubble velocities can now be inferred from cross-correlation of two probe signals, and the numerical modeling has yielded circulation streamlines for a bubble column in laminar flow. Liquid velocities can also be measured in a hexagonal test column with the laser doppler velocimeter. Details of this research progress follow. 12 refs., 41 figs.

7105 (EUR-11808) **Selective hydrocarbon synthesis: Demonstration project: Final report.** Commission of the European Communities, Luxembourg (Luxembourg). c 1988. 23p. Sponsored by Commission of the European Communities. Available from NTIS (US Sales Only), PC A03/MF A01; Office for Official Publications of the Eruopean Communities, 2, rue Mercier, L-2985 Luxembourg.

The TIGAS process is characterized by a large degree of integration of the three process steps involved, synthesis gas production, oxygenate synthesis and gasoline synthesis. The main idea has been to eliminate costly interconnecting unit operations between the individual process steps such as synthesis gas compression, condensation and evaporation of methanol and separate dehydration of methanol to dimethylether. The integration has been achieved by integrating the two process steps, methanol synthesis and gasoline synthesis into one single synthesis loop without any isolation of MeOH as intermediate. Another key element in the integration has been the use of a new process for combined synthesis of methanol and dimethylether developed by Haldor Topsoe A/S instead of conventional methanol synthesis. To demonstrate the TIGAS process, an industrial pilot with a capacity of 1 MTPD of gasoline has been erected. The demonstration plant is a semi-industrial unit. The flow scheme, compressors, heat exchangers, separators, piping and instrumentation are as foreseen in an industrial plant. 12 figs., 7 tabs.

1006 Health and Safety

7106 (ANL/ES-163) **Environmental, health, and safety concerns associated with nonpetroleum fuel use in US transportation: Progress report 1.** Rajan, J.B.; Saricks, C.L.; Singh, M.K.; Walsh, W.J. Argonne National Lab., IL (USA). Jun 1989. 57p. Sponsored by U.S. DOE Management & Administration. DOE Contract W-31109-ENG-38. Order Number DE90004367. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This report qualitatively examines the environmental, health, and safety concerns associated with the use of three alternative fuels in the US transportation system: methanol, compressed natural gas, and electricity. For each of these fuels, this report presents the results of a literature review, discussions with specialists, and recent data from in-use fleet tests and summarizes the state of knowledge of their potential air pollution contribution from end use and process emissions relative to gasoline and diesel fuels. Carbon monoxide, particulate matter, ozone precursors (oxides of nitrogen and volatile organics), and carbon dioxide (from processing activities) are emphasized. Methanol-fueled vehicles are expected to have emissions comparable to their gasoline counterparts at least during the initial years, albeit with higher emissions of formaldehyde. Methanol production from coal may result in higher emissions of carbon dioxide. Compressed natural gas vehicles have the potential to reduce emissions of carbon dioxide and nonmethane hydrocarbons relative to conventional fuels. Electric vehicles using recharge power from nuclear or renewable energy sources hold the greatest promise for reduced air emissions. The manufacture and disposal of materials from lead-acid and nickel-iron batteries present safety concerns related to the potential emission of toxic materials. 69 refs., 7 figs., 8 tabs.

1009 Environmental Aspects

Refer also to citation(s) 7672

13 HYDRO ENERGY

Refer also to citation(s) 7746, 8058

1301 Resources and Availability

Refer also to citation(s) 7370

7107 (ETSU-SSH-4063-P2) **Small scale hydroelectric generation potential in the UK. V. 2: Detailed site data.** UKAEA Harwell Lab. (UK). Energy Technology Div. 1989. 157p. Available from Available from the British Library Document Supply Centre, Boston Spa, Wetherby, West Yorks. LS23 7BQ.

During the period May 1987 to October 1988, Salford University Civil Engineering Limited undertook an appraisal of the economic potential for small-scale hydro-electric generation in the U.K.. The main report of this study, Volume I, contained details of the scope and terms of reference for the study, methods of appraisal, results and conclusions thereon. This volume presents data on each site considered in detail. This data relates to geographical location, physical site parameters, meteorological and hydrological characteristics, power and energy yield estimates and economic analyses. (author).

7108 (OH/RD-88-327-K) **Long-term forecasts for the Niagara River flows.** Camacho, F. Ontario Hydro Research Div., Toronto, ON (Canada). 24 Feb 1989. 95p. (MICROLOG-89-04432).

Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

An assessment study of the forecasting model used by Ontario Hydro to obtain six-years-ahead forecasts for the Niagara River flows was carried out. The objective of the study was to evaluate the forecasting ability of the model and to determine whether the model could be improved upon. A Forecasting competition is used, with the root mean square error (RMSE) as the index of the forecast ability. A total of 33 models and 18 validation periods are included in the competition. The results indicate a strong dependency of the performance of the models on the type and length of the validation period. Based on the results for the longest validation period it is found that either the routing model alone or a combination of the routing and the periodic autogressive models can improve the current model, and for either of these models, the RMSE values of the forecasts for the first year are between 20% and 40% smaller than the corresponding RMSE values obtained by a model whose forecasts are based only on the long-term monthly means; however, these improvements rapidly diminish as the forecast period increases. The computer code FORECAST is described in an appendix. 13 refs., 11 figs., 3 tabs.

1302 Site Geology and Meteorology

7109 (OH/RD–88-323-K) **R.H. Saunders GS [generating station] - Bedrock study geochemical investigation.** Shou, Z.; Dayal, R. Ontario Hydro Research Div., Toronto, ON (Canada). 19 Dec 1988. 19p. (MICROLOG–89-04587). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

In this report, the authors present a brief review of the pertinent literature on gypsum dissolution, with particular reference to the relevant geochemical approaches employed to evaluate void formation and enlargement in the foundation rock. Aa geochemical evaluation of the existing water chemistry data from the R.H. Saunders Generating Station site is also presented. 6 refs., 5 figs., 4 tabs.

1303 Plant Design and Operation

Refer also to citation(s) 7612

7110 (OH/RD–88-281-K) **Decew Falls GS [generating station] no.1: Ecaluation of headworks concrete.** Aita, D.; Caratin, H. Ontario Hydro Research Div., Toronto, ON (Canada). 3 Jan 1989. 19p. (MICROLOG–89-04440). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

Samples of concrete were obtained by drilling cores from the headworks piers of DeCew Falls Generating Station No. 1. The condition and physical properties of the concrete were evaluated. A total of three cores were drilled, one from each of piers 4, 5, and 6. The structure incorporated two types of concrete, old (1898) and new (1947). Both concretes, although non-air-entrained, are still in good condition. The density, absorption characteristics, ultrasonic pulse velocity and compressive strength of the drill cores have been measured. The average compressive strengths of the old and new concretes are 35.4 and 52.2 MPa, respectively. A further evaluation of the condition of the concrete should be conducted after the forebay is dewatered. 13 figs., 4 tabs.

1305 Economic, Industrial and Business Aspects

7111 (BCH/RP–89-03823) **B.C. Hydro electric load forecast 1988/89-2008/09.** British Columbia Hydro, Vancouver, BC (Canada). Resource Planning Corporate Affairs. 1988. 68p. (MICROLOG–89-03823). Available from PC B.C. Hydro, 970 Burrard St., Vancouver, BC, CAN V6Z 1Y3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

This document presents the probable economic and energy forecast for B.C. Hydro. The document includes current electricity supply and use, load growth, and electricity versus the gross domestic product in British Columbia. Background information is given on the economic forecasts by sector, as well as a description of the methodology used. Also included are the probability distribution and uncertainty for the electricity forecasts and the probable effect of the Power Smart and other marketing programs. 43 figs., 15 tabs.

7112 (ORNL/FTR–3487) **[Hydroelectric project in Costa Rican rural electric generation and transmission]: Foreign trip report, November 6–16, 1989.** Waddle, D.B. Oak Ridge National Lab., TN (USA). 28 Nov 1989. 6p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90003971. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

On November 6, 1989, I left for San Jose, Costa Rica. My visit was set to accomplish two activities. The first activity was a follow-on mission to gather additional information on a newly identified small hydroelectric project, in support of a rural electric generation and transmission cooperative performed for the Renewable Energy Applications and Training project. Data on stream flows, soils, geologic, and topographic information was gathered for Rio San Lorenzo, near Quesada. A reconnaissance level survey was performed for Rio Naranjillo, a river near San Marcos. The second part of the visit was dedicated to interaction with ICE, the electric utility, discussing plans to establish a comprehensive efficiency program in Costa Rica. I returned to Oak Ridge on November 16, 1989.

1306 Environmental Aspects

7113 (OH/RD–88-103-K) **Effectiveness of a sound deterrent in excluding gizzard shad at Lambton TGS [thermal generating station]: Preliminary laboratory and field results.** Patrick, P.H.; McKinley, R.S. Ontario Hydro Research Div., Toronto, ON (Canada). 17 Nov 1988. 18p. (MICROLOG–89-04450). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

The effectiveness of sound in eliciting a response from gizzard shad was investigated. Preliminary laboratory results suggested that juvenile gizzard shad elicited a negative avoidance response to a sound device at frequencies ranging from 41 to 422 Hz, but only when the sound amplitude level was increased. Four hammer sound deterrents were placed in front of the Lambton Generating Station intake during early winter. The effectiveness of these devices in reducing the number of shad entering the intake was not evaluated because of the low number of fish in the proximity of the intake during experimentation. However, preliminary experiments were conducted at the discharge. The hammer elicited a negative response from the shad present in the discharge for the different signal frequencies evaluated. The extent of the influence was limited to less than 5 m. Preliminary results indicated that gizzard shad failed to acclimate to the sound stimulus for a period of at least two hours using a frequency signal of 80 and 500 Hz. 2 refs., 7 figs.

1307 Power-Conversion Systems

Refer also to citation(s) 7491

14 SOLAR ENERGY

Refer also to citation(s) 7149, 7693, 7883

7114 (SERI/CP–211-3550, pp. 1-6) **Overview of polycrystalline thin films.** Zweibel, K. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

The polycrystalline thin films ($CuInSe_2$ and CdTe) have become the leading thin films. That means that they have attained the highest cell efficiencies (14.1% for CIS and 12.3% for CdTe), the highest submodule efficiencies (11.1% CIS and 7.3% CdTe on a square foot; 9.1%, 4 square feet for CIS); the best stabilities (CIS 200 days without degradation), and are made by the lowest-cost processes (spraying, electrodeposition, sputtering, selenization). There are relevant issues to CIS and CdTe research still needing attention. Indium availability and Cadmium use and disposal are areas that must be researched in order to bring CIS and CdTe technology to maturity.

7115 (SERI/CP–211-3550, pp. 7-16) **An assessment of solar hydrogen energy systems: implications of advances in thin film solar cell technology.** Ogden, J.M. (Princeton Univ., NJ (USA)); Williams, R.H. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

Hydrogen is a high quality, exceptionally clean–burning fuel, which could replace oil and natural gas for transportation, heating and power. If hydrogen is made via solar photovoltaic (PV) powered water electrolysis, it would be possible, in principle, to provide energy on a global scale, with no greenhouse gas emissions and very low pollution. An overview of solar hydrogen energy systems is presented which includes production costs,land requirements, and usage of this thin film technology.

7116 (SERI/CP–211-3550, pp. 17-26) **Progress on polycrystalline thin film CdTe modules.** Albright, S.P. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

A research program addressing the common objectives between PEI and DOE regarding large-area low-cost terrestrial photovoltaics is presented. The object of the program is to improve materials technology and fabrication processes for limited volume production of 1 ft^2 and 4 ft^2 CdS/CdTe photovoltaic modules. The research program is divided into four separate tasks: Performance optimization on small cells; Analyses and characterization of CdS/CdTe devices; Encapsulation and stability testing; Panel efficiency optimization. Major technical results and milestones for each task are presented.Future development plans are also discussed.

7117 (SERI/CP–211-3550, pp. 35-44) **Thin film II-VI compound solar cells.** Chu, T.L. (Univ. of South Florida, Tampa (USA)); Chu, S.S. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

The use of solution-grown CdTe as the TCS has been investigated in detail. Because of its porosity and reactivity, the characteristics of CdS/CdTe cells are inferior to those prepared from CdS prepared at high temperatures. There are indications that the densification of solution-grown CdS can be achieved. Adherent ZnTe films have been deposited by MOCVD, and the deposition processes must be optimized for improved junction characteristics. Experimental results from tests of TCS films by solution growth, deposition of CdTe films and junction structures, and ZnTe films and junctions are presented.

7118 (SERI/CP–211-3550, pp. 45-52) **Current status and future directions of Cd(Zn,Mn)Te/CdS solar cells.** Rohatgi, A. (Georgia Institute of Technology, Atlanta (USA)); Summers, C.J.; Erbil, A. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

CdTe is a promising material for high efficiency thin film solar cells due to its near optimum 1.45 eV bandgap, ease of deposition, and strong optical absorption. CdZnTe and CdTe films were grown by molecular beam epitaxy (MBE) on CdS/SnO_2/glass substrates. CdMnTe and CdTe films were grown by metal organic chemical vapor deposition (MOCVD). Front wall solar cells were fabricated with a glass/SnO_2/CdS/CdTe or Cd(Zn,Mn)Te/ZnTe/Ni structure. XPS measurements were performed on annealed CdZnTe films after $Br:CH_3OH$ etch. Surface photovoltage, depth-resolved Auger measurements, spectra response, and X-ray photoelectron spectroscopy measurements were performed to characterize the materials and devices.

7119 (SERI/CP–211-3550, pp. 53-60) **Japanese polycrystalline thin film activity under the sunshine project.** Katsuaki Sato (Tokyo Univ. of Agriculture and Technology (Japan)); Tetsuro Kobayashi. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

Research activity in polycrystalline thin film solar cells under the Sunshine Project is summarized. Until recently most of the research and development have been concentrated on amorphous and crystalline silicon solar cells. Polycrystalline compound semiconductor films have been studied as bottom cells for tandem structure with the amorphous silicon cell. A remarkable conversion efficiency has been reported in large area polycrystalline cells of CdS/CdTe prepared by the screen printing and sintering technique. Preparation of $CuInSe_2$ films has been attempted by means of the screen printing/sintering and spray pyrolysis. The related activities independent of the project will also be summarized briefly.

7120 (SERI/CP–211-3550, pp. 61-70) **First-principles phase diagram calculation of II-VI semiconductor alloys.** Suhuai Wei; Ferreira, L.G.; Zunger, A. Solar Energy Research Inst., Golden, CO (USA). [1989]. DOE Contract AC02-77CH00178. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

The first-principles calculations of the temperature-composition phase diagrams for some of the II-VI semiconductor alloys have been performed. The calculated results are in good agreement with available experimental data. The calculation method is simple and can be easily applied to other systems. This method provides a controlled and converged calculations of the phase diagram and all thermodynamic properties directly from an ab initio Hamiltonian.

7121 (SERI/CP–211-3550, pp. 71-76) **Photoluminescence studies of CdTe polycrystalline thin films.** Abou-Elfotouh, F.; Dunlavy, D.J.; Ullal, H.S. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

Photoluminescence (PL) emission from p-type CdTe polycrystalline thin films is reported at low temperatures (9-50°K) as well as room temperature. The room temperature (PL) peak at 1.58 eV due to band-to-band recombination was observed for the first time in polycrystalline thin films. The CdTe (PL) spectrum consists of two groups of emission lines that belong to two different energy regions. The near-band edge emission is attributed to free and bound exciton transitions associated to V_{Cd}, and the lower energy emission is attributed to donor (D)-acceptor (A) recombinations. The electrical properties of the samples determine the type of PL spectrum.

7122 (SERI/CP–211-3550, pp. 77-86) **Post processing treatments and contacts for thin film CdS/CdTe devices.** Birkmire, R.W. (Univ. of Delaware, Newark (USA)); McCandless, B.E.; Phillips, J.E. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

CdTe/CdS solar cells have been made with efficiency over 9.5% by a physical vapor deposition process. A post deposition process has been developed which optimizes the overall device performance and allows the effect of the processing steps on the device

to be separated. Comparison of the I-V data and shape of the quantum efficiency curves through the CdS and transparent Cu/Au contact just after the contact was deposited shows that the device operates similar to a p-i-n cell.

7123 (SERI/CP–211-3550, pp. 87-92) **$Cd_{1-x}Zn_xTe$ films and devices obtained by two-stage processes.** Basol, B.M. (International Solar Electric Technology, Inglewood, CA (USA)). Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851– : Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

This research has demonstrated the use of the two-stage process for the preparation of $Cd_{1-x}Zn_xTe$ alloy films. Cost effective electrodeposition steps can be used in the two-stage process is also demonstrated. Solar cells on films have been prepared by this technique. These devices need further improvement but the preliminary results are promising. The next phase of the research will focus on the efficiency improvement of the devices.

7124 (SERI/CP–211-3550, pp. 93-98) **Ion-assisted doping of CdTe films.** Bube, R.H. (Stanford Univ., CA (USA)); Fahrenbruch, A.L.; Chien, K.F.; Kim, K.; Lopez-Otero, A.; Sharps, P. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851– : Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

Ion-assisted doping, IAD, during physical vapor deposition growth of p-CdTe films for solar cells has been investigated as a means to obtain higher doping densities than those previously obtained with conventional film deposition processes. The experimental apparatus includes a conventional Knudsen effusion cell for the CdTe (evaporated from the compound), an ionizer with a graphite anode and extraction grid, a W filament electron source, and a BN effusion cell for the dopant, either elemental As of red P. Experimental results are presented.

7125 (SERI/CP–211-3550, pp. 99-102) **Chemical beam epitaxy for II-VI solar cell materials.** Summers, C.J. (Georgia Technology Research Institute, Atlanta (USA)); Rohatgi, A. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851– : Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

This research presents new techniques for the growth of II-VI materials. These include a Te-condensation method for substrate temperature measurement and the development of a photon-assisted chemical beam epitaxial system for growth, which appears to have significant potential both for improving the understanding of II-VI growth processes and for growing high-quality layers.

7126 (SERI/CP–211-3550, pp. 103-108) **Outdoor stability performance of CIS (Copper Indium Diselenide) and CdTe (Cadmium Telluride) photovoltaic modules at SERI (Solar Energy Research Institute).** Mrig, L.; Rummel, S. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

SERI has been conducting tests to study the outdoor stability performance of presently leading thin-film technologies of Amorphous Silicon, Copper Indium Diselenide (CIS), and Cadmium Telluride (CdTe) modules and submodules. This work describes stability performance test results from tests conducted at SERI on Copper Indium Diselenide (CIS) and Cadmium Telluride (CdTe) thin-film material modules and submodules over a period of several months.From the test data it appears that stability characteristics of CIS modules exhibit none or little degradation over the initial testing period at SERI while there is need to improve the encapsulation system on the CdTe test structure.

7127 (SERI/CP–211-3550, pp. 109-118) **Implications for the physics of operation of $CuInSe_2$ solar cells derived from numerical models.** Schwartz, R.J. (Purdue Univ., West Lafayette, IN (USA)). Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

The successful application of a numerical model to the design and analysis of a solar cell requires a model which accounts for the important physics of operation, employs the proper numerical techniques and contains the correct microscopic materials parameters. In the case of $CuInSe_2$ (CIS) cells the numerical model TFSSP (previously developed at Purdue) for a-Si cells, has been adapted to their analysis. Two recombination mechanisms have been proposed to be the dominant processes which limit the performance of CIS solar cells. One mechanism is recombination at the emitter-base interface and is usually attributed to a high density of interface states. The other mechanism is the usual HSR recombination through deep levels in the bulk of the material. The numerical models for CIS solar cells are in an early stage of development and will require considerable comparison with experiment before they become predictive in the same way that the single crystal models have.

7128 (SERI/CP–211-3550, pp. 119-122) **Incremental photocurrent analysis for polycrystalline thin-film solar cells.** Sites, J.R. (Colorado State Univ., Fort Collins (USA)). Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

The goal of this research project is to increase the useful information extracted from relatively straightforward electrical measurements from polycrystalline thin-film solar cells. This report will show the functional form, potential magnitude, and expected wavelength dependence of each photocurrent modification mechanism. Using data from CdTe and $CuInSe_2$ cells, as well as crystalline silicon for reference, it is suggested that series resistance usually accounts for most of the voltage dependence of incremental photocurrent. However, there are situations involving low temperatures, large leakage, significant photoconductivity, excessive recombination, or poor experimental technique where other factors must be included in the analysis.

7129 (SERI/CP–211-3550, pp. 123-130) **Device analysis relevant to the understanding of current-voltage behavior of heterojunction solar cells.** Phillips, J.E. (Univ. of Delaware, Newark (USA)); Birkmire, R.W.; McCandless, B.E.; Roy, M.; Shafarman, W.N. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

By analyzing the current-voltage behavior and spectral response of thin film $CuInSe_2$/(CuZn)S and CdS/CdTe polycrystalline solar cells with transparent contacts, it has been possible to determine and quantify the mechanisms controlling device behavior under illumination. Spectral response measurements have enabled the researchers to determine diffusion lengths, absorption coefficients, and also show that interface recombination can be neglected. These techniques are now being applied to high efficiency CdTe/CdS devices as well.

7130 (SERI/CP–211-3550, pp. 131-134) **Ordered-vacancy-compound semiconductors: Pseudocubic $CdIn_2Se_4$.** Bernard, J.E.; Zunger, A. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

Substitutional adamantine compounds have four metal atoms around each nonmetal atom and vice versa. Ordered-vacancy compounds (OVC's) have three metal atoms around each nonmetal site while the fourth (unoccupied) site forms an ordered array of vacancies. An example for OVC's is pseudocubic $CdIn_2Se_4$ which can be

structurally derived from the layered alternate monolayer superlattice of CdSe and InSe by removing half of the Cd atoms from each Cd plane. This report studies the properties of such an ordered array of vacancies in $CdIn_2Se_4$ vis-a-vis the experimental data. The nature of the bonding in this system, comparing it to other covalent selenides and to the observed photoemission and optical data is also discussed.

7131 (SERI/CP–211-3550, pp. 135-136) **Copper-indium-diselenide: Atomic-level analysis.** Kazmerski, L.L. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

This report presents further results on atomic-level and microanalytical studies of defects in copper-indium-diselenide, and the incorporation of impurities and host species at internal defects and at the surfaces of this photovoltaic semiconductor. Defects in polycrystalline $CuInSe_2$ are identified, with some emphasis on the resolution of grain boundary types in the chalcopyrite lattice. SSTM images of common cleave-planes are provided, with atomic images of the inherent Cu, In, and Se for the $CuInSe_2$, and also the Ga for $CuInGaSe_2$. Many first-time observations of atomic-level events are provided that might be useful to research groups involved with this semiconductor.

7132 (SERI/CP–211-3550, pp. 145-156) **Characterization of $CuInSe_2$ thin films electrodeposited from aqueous solutions.** Pern, F.J.; Mason, A.; Dolan, J.; Noufi, R. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

This report details the study of the structure characteristics for the thin films of electrodeposited $CuInSe_2$, effects of annealing conditions, chemical etching, and the solution electrochemistry. These are looked at in order to better control the various factors that influence the deposition mechanisms and post-deposition treatments in order to produce high quality electrodeposited $CuInSe_2$ thin films for solar cell applications. Tetragonal chalcopyrite on Cu-rich films and cubic sphalerite in In-rich films was observed. Results from this study are presented and discussed.

7133 (SERI/CP–211-3550, pp. 157-160) **Electrodeposited thin films and Bridgman-grown $CuInSe_2$.** Qiu, C.X. (McGill Univ., Montreal, Quebec (Canada)); Shih, I.; Qiu, S.N.; Weng, W.S.; Yip, L.S.; Champness, C.H. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

Recently, a new program for the growth of $CuInSe_2$ has been started in this laboratory using a vertical growth apparatus with slower growth rate capability and r.f. induction heating in a graphite susceptor. The object is to explore the properties of the crystalline compound with controlled deviation from stoichiometry and to obtain information on how the open circuit voltage can be increased in photovoltaic cells prepared from this material. The preparation of bulk $CuInSe_2$ will be described. A method developed for a one-step electrodeposition process for the preparation of $CuInSe_2$ thin films will also be discussed.

7134 (SERI/CP–211-3550, pp. 161-162) **Growth, characterization, and solar cell performance of hybrid-sputtered $CuInSe_2$ thin films.** Rockett, A. (Univ. of Illinois, Urbana (USA)); Tseng, B.H.; Talieh, H.; Lommasson, T.C. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

Solar cells with conversion efficiencies exceeding 7% have been fabricated based on $CuInSe_2$ produced by a hybrid process combining sputtering of Cu and In with evaporation of Se. This process has been shown to be highly controllable with linear relationships observed between the target ion currents and the metal-constituent content of the resulting films. To demonstrate the quality of the $CuInSe_2$, heterostructure solar cells have been fabricated by the authors, the Institute of Energy Conversion at the University of Delaware (IEC), and International Solar Energy Technology (ISET). Some variation in performance is observed as a function of the average bilayer composition with more uniform performance in relatively In-rich layers and greater variation when higher amounts of Cu were present.

7135 (SERI/CP–211-3550, pp. 163-170) **Photovoltaic device fabrication strategies in $CuInSe_2$ based multinary alloy structures.** Tuttle, J.R.; Albin, D.S.; Noufi, R. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

The object of this work is to develop strategies for moderate to high risk modifications to the standard co-evaporated $CuInSe_2$ based device structure in hope of improving on the present state-of-the-art technology. The authors are interested in achieving increases in open-circuit voltage and short-circuit current by one of the following four techniques; 1. Ga incorporation in the space charge region (SCR) in the form of either (In,Ga) alloys or discrete $CuGaSe_2$; 2. $CuGaSe_2$ incorporation at the rear contact; 3. modification of compositional profile of the standard $CuInSe_2$ bilayer structure; 4. surface/interface modifications targeting a reduction in N_{ir}, interface recombination centers, and J_o, reverse saturation current. Combining one or all of the above techniques into a single high efficiency device structure is the ultimate goal. Experimental procedure and results are presented.

7136 (SERI/CP–211-3550, pp. 171-176) **Thin film solar cells based on $CuInSe_2$ and related compounds - R and D in Europe.** Schock, H.W. (Universitaet Stuttgart (West Germany)). Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

The authors summarize the research and development work on polycrystalline compound semiconductors performed in Europe. Work on Cu_2-CdS solar cells has been done for 20 years, involving several commercial companies. Presently, research on thin film solar cells is carried out mostly in university laboratories, sponsored by local institutions or by the commission of the European communities (CEC). The objectives of the research was the realization of $Cu(In,Ga)Se_2$-based solar cells with different technologies. An overview of the various research projects are presented.

7137 (SERI/CP–211-3550, pp. 177-186) **Fundamentals of polycrystalline thin film materials and devices.** Birkmire, R.W. (Univ. of Delaware, Newark (USA)); Phillips, J.E. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

The major objective of this research is to gain a deeper understanding of the materials, processing, and device issues needed to improve the performance, reliability, and cost of polycrystalline thin film solar cells. A further objective of this research is to support the efforts of the SERI polycrystalline thin film task through collaboration with other research groups, especially the thin film industry. $CuInSe_2$ films have been grown by selenization of Cu/In layers and cells have been made with efficiency over 7%. Post deposition processing and contacting steps have been developed to optimize CdTe/CdS cells, independently of the way the cell is made. The mechanisms controlling device behavior under illumination for both $CuInSe_2$ and CdTe solar cells have been determined by analyzing the current-voltage and spectral response behavior.

7138 (SERI/CP–211-3550, pp. 187-192) **$Cu(In,Ga)Se_2$ films and devices obtained by the two-stage process.** Kapur, V.K. (International Solar Electric Technology, Inglewood, CA (USA)); Basol, B.M. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting,

Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

The goal of this research program is to develop high efficiency $Cu(In,Ga)Se_2$ solar cells using a two-stage process. In this work $Cu(In,Ga)Se_2$ films of various stoichiometries have been prepared by the two-stage process and $CdS/Cu(In,Ga)Se_2$ heterojunction solar cells with close to 11% efficiency have been fabricated on these films. The authors future work will concentrate on the further development of the two-stage process utilizing evaporation for the fabrication of submodules and for the improvement of the device efficiencies to the 12-15% range.

7139 (SERI/CP–211-3550, pp. 193-198) **High efficiency $CuInGaSe_2$ based solar cells and materials research.** Devaney, W.E. (Boeing Electronics High Technology Center, Seattle, WA (USA)); Chen, W.S.; Stewart, J.M. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

The results of the recently completed research program will be presented. A $ZnO/CdZnO/CuInGaSe_2$ solar cell with a total area efficiency of 12.5% has been fabricated. A focus of the research program has been on the analysis of the optical and electronic structure of these high efficiency $ZnO/CdZnO/CuInGaSe_2$ devices. A detailed description of the characteristics of the device will be given. Results on gallium doping of CdZnS window layers and antireflection coatings will be presented.

7140 (SERI/CP–211-3550, pp. 199-208) **Status of $CuInSe_2$ cells and submodules.** Mitchell, K.W. (ARCO Solar, Inc., Camarillo, CA (USA)). Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

The primary goal of this research is to develop stable, 13% efficient tandem thin film modules. To achieve this goal, ARCO Solar has pursued development of four-terminal tandem devices that use a thin film Si:H alloy (TFS) device as the top component and a $CuInSe_2$ (CIS) device as the bottom component. The primary advantage of this approach is the physical decoupling of the two circuits. Modeling calculations indicate practical, achievable efficiencies in the range of 20% for this combination. The progress of phase I and phase II is discussed as well as where the bulk of research time will be spent. One area of research is in developing environmentally durable packages for large area submodules.

1401 Resources and Availability

Refer also to citation(s) 7113

7141 (JSES–880, pp. 5-8) **Simple integrated-recording film for measurement of TOT. Total sky radiance.** Yoshimura, Takao (Chiba Univ. (Japan)); Ishikawa, Toshio. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSET-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Although there are a variety of measuring instruments for sky radiance to which photocells and thermocouples are applied, most of them are not simple enough for the measurement of the amount of solar radiation. There may be a wide area of application for a simple integrated piranometer. A new low cost integrated-recording film for measurement of total sky radiance was developed which makes use of fading of dyes and is applicable on ground leaf, in water, etc. for simultaneous multi-point measurement. Several kinds of the dye (PAN, Oil Red O, Sudan I, Sudan IV) films brought about good results. Fading of dye was applied in the development of this sensor, and impregnation method of dye to cellulose acetate film base was employed as a means of achieving comparatively uniform coating with little influence by oxygen or ultraviolet ray. Fading of dye under light in various conditions were experimented to find the conditions for practical applications. 5 refs., 5 figs., 3 tabs.

7142 (JSES–880, pp. 9-12) **Measurement of solar radiation from high-luminance sky around the sun.** Akasaka, Hiroshi (Kagoshima Univ., Kagoshima (Japan)); Kuroki, Soichiro; Ninomiya, Hideyo; Inamura, Tomonari. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

For the evaluation of indoor thermal environment, it is desirable to consider solar radiation emitted from high luminance sky around the sun (semi-direct solar radiation) as a part of direct solar radiation. The simi-direct solar radiation has, however, not been quantitatively clarified. Different from the conventional representation method of semidirect solar radiation by direct solar radiation, a method of representation by the sky solar radiation standard has also been studied. A solar piranometer with a sun chasing and shading circular plate over it has been framed to study the semi-direct solar radiation quantitatively. Simultaneous measurement by this system together with a total solar piranometer and a direct solar piranometer will give the semi-direct solar radiation for each angle of shading. The features of the chasing type solar piranometer are presented. The effect of the height of the sun on the semi-direct solar radiation was evaluated and a better formula was derived. The effect of atmospheric transmission was observed also with this method. It seems to be necessary to accumulate measured data and study the effect of atmospheric transmission. 4 refs., 9 figs.

7143 (JSES–8801, pp. 1-4) **Influence of obstructions on solar radiation. Model and evaluation.** Yoshida, Sakumatsu. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

The effect of the presence of obstructions on the solar radiation must be estimated in applying solar energy. Several models have been presented so far for the study of the effect, but none of them has been evaluated comparing with measured data. This study has been carried on under the contract awarded by NEDO, and the objective is to develop an estimating method of the influence of obstructions on the monthly mean solar radiation on an inclined surface. First, a model is presented for estimating the influence of obstructions on the monthly mean solar radiation and sky solar radiation as well as the solar radiation reflected by the obstructions. The estimated values by the model are compared with the measured values obtained by the observation at Tsukuba Science City. As a result, the degree of errors in the estimation of influence by obstructions were made clear. Further application of this model to solar radiation on inclined surfaces shall be reported later. 8 refs., 5 figs., 2 tabs.

1403 Economic, Industrial, and Business Aspects

7144 (CONF-8704378–1) **Italian bioclimatic architecture.** D'Errico, E. ENEA, Rome (Italy). Apr 1987. 4p. From European conference on architecture; Munich (Germany, F.R.); 6-10 Apr 1987. Order Number DE89761951. Available from NTIS (US Sales Only), PC A02/MF A01.

This paper deals with the results of solar space heating research developed within the Finalized Energy Project of the National Research Council of Italy. Energy and cost/benefit parameters were compared for a certain number of Italian buildings incorporating solar architecture. The technical and economic analysis was performed on 31 buildings, of which 24 are residential, and 7 are schools, with different solar devices (direct gain, Trombe walls, sunspaces, hybrid systems). The buildings were constructed between 1976 and 1982. The results emphasize that simple technologies with lower costs and good design usually have a higher performance/cost ratio.

1405 Solar Energy Conversion

Refer also to citation(s) 7113, 7114, 7115, 7116, 7117, 7118, 7119, 7120, 7121, 7122, 7123, 7124, 7125, 7126, 7127, 7128, 7129, 7130, 7131, 7132, 7133, 7134, 7135, 7136, 7137, 7138, 7139, 7696, 8027, 8141, 8544

7145 (ETDE-mf–0732473) **Photovoltaic systems - an overview of the market.** Werkstattreihe. Meereis, J. Institut fuer Angewandte Oekologie e.V., Freiburg im Breisgau (Germany, F.R.). Nov 1987. 42p. (In German). Order Number DE90732473. Available from NTIS (US Sales Only), PC A03/MF A01.

The aim of this market data compilation is to aid the orientation of potential users of photovoltaic power sources. With this in mind, an inquiry was made in autumn '87 among business men in the retail and wholesale trade in the Federal Republic of Germany, Switzerland, and Austria. The publication contains not only a directory of suppliers but also a series of technical data on the available products. Because of the lack of detailed information regarding specific applications, a warning is given against using solar modules including the pertaining system technology without seeking thorough technical advice previously. (ORU).

7146 (JSES–8801, pp. 177-180) **Conversion of solar energy into hydrogen energy by high-temperature steam electrolysis.** Arashi, Haruo (Research Inst. for Scientific Measurements, Tohoku Univ., Sendai, Japan); Miura, Hisashi; Ishigame, Mareo. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

In the steam electrolysis at high temperatures of about 1,000°C, a free energy change of decomposition reaction becomes small, decomposition voltage decreases, overvoltage of electrodes also decreases due to the fast progress of the electrode reaction, electric energy consumption become less, hence hydrogen can be produced highly efficiently. Because of the above, if the high temperatures above are generated by solar energy, production of hydrogen through the self-contained high temperature steam electrolysis is possible. This article is a report of the experiment of high temperature steam electrolysis (hereinafter referred to as electrolysis) using the electrolytic function of zirconia-based oxidant with a high melting point on the basis of the above concept. Firstly, the electrolysis by heating with an electric furnace was experimented, than the electrolysis using a cylindrical laminated electrolysis cell was experimented in order to make the surface area of the electrolyte larger for increasing the total amount of hydrogen generated. Furthermore, the electrolysis using a solar furnace simulator was tried. As a result, it was confirmed that hydrogen could be obtained highly efficiently and it was found that the electrolysis by soiar energy was effective for hydrogen production. 13 figs.

7147 (JSES–8801, pp. 181-184) **Study on home-kitchen garden-type solar system.** Wakabayashi, Heiji; Adachi, Masao. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

This article is an introduction of the home-kitchen garden-type solar system which Ashi-no-kai (Group of reeds) organized in Kanazawa proposes. The system aims at self-support of energy, prevention of eutrophication of rivers, recycling of water resources, enrichment of the soil and supply of safe and fresh foods. The soil is enriched by making well matured compost through a compost-making toilet. For the utilization of solar energy, solar cells and a solar water heater are used. The study also proposes the multiple-purpose utilization of the land by expanding the above system to an area. 4 refs., 7 figs, 1 tab.

7148 (JSES–8801, pp. 165-168) **Study on light energy-conversion system (V). Trials of making highly efficient LSC film.** Higuchi, Yoichi (Tokai Univ., Tokyo (Japan)); Miyasaka, Nobutoshi; Nakamura, Ken'ichiro. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

In this study, as trials of forming LSC films whose luminous efficacy was much higher than the case of the previous report, firstly the formation of LSC films was conducted by dispersion of pigmented new color through letting titanium oxide with high selective permeability characteristics adsorb fluorochrome. Secondly, a LSC film was experimentally made in which the fluorochromes of more than two constituents were dispersed in a sheet of film and evaluation of its fluorescence emission characteristics and fluorescent quantum yield was conducted. This article is its report. In other words, in the first trial above, it became possible that by fixing color with TiO_2, a LSC single plate could have selective permeability characteristics at the same time. In the second trial, quantum efficiency could be improved to be not less than 0.75 and because of this, it has been considered that the further application of a LSC film to an efficient light energy conversion system by this method be feasible. 5 refs., 4 figs., 1 tab.

7149 (NAL-TR–994) **Experimental component mode synthesis applied to the solar array type structure.** Komatsu, Keiji; Sano, Masaaki; Sanbongi, Shigeo; Kai, Takashi; Toda, Susumu. National Aerospace Lab., Chofu, Tokyo (Japan). Aug 1988. 23p. (In Japanese). Order Number DE89910140. Available from NTIS (US Sales Only), PC A03/MF A01.

As the satellites gets bigger, power demand is accordingly increasing as well as the solar cell paddles. This is one typical structure in the space structures which is flexible. For this structure, various tests for the parts are conducted which are fed back to a finite element model, and the dynamic characteristics on the orbits are estimated by calculation. Roles of the mode synthesis at this time is to cross-check the combined structural analysis made by the finite element model. In this report, mode synthesis, based on a parts test concerning a paddle of an open-isogrid was conducted, wherein a good result was obtained by comparing with the combined structure test. The success is attributed to the followings: 1. Data of the rigid body mode of the part structure was theoretically given. 2. Rigidity of the connecting part was identified by the tests. 3. Degree of freedom of rotation was established by a polynomial approximation. 5 refs., 10 figs., 3 tabs.

7150 (SERI/CP–211-3550, pp. 27-34) **Polycrystalline CdTe n-i-p solar cell and module development.** Meyers, P.V. (Ametek, Inc., Harleysville, PA (USA)); Liu, R.C.H.; Ramanathan, V.; Russell, L. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

The major objectives of this research are the improvement of efficiency and stability to CdTe based solar cells. More transparent window layers are used to increase efficiency. Device stability is also considered. Results from experiments with respect to CdS window layer, ZnTe, Loss analysis, Cascaded solar cells, Module fabrication, and module stability are presented.

7151 (SERI/TP–211-3604) **Progress in thin film solar photovoltaic technologies.** Ullal, H.S.; Zweibel, K. Solar Energy Research Inst., Golden, CO (USA). Dec 1989. 12p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC02-83CH10093. (CONF-891210–1: 9. Miami international congress on energy and environment, Miami Beach, FL (USA), 11-13 Dec 1989). Order Number DE89009513. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This paper focuses on the rapid recent advances made by thin film solar cell technologies, namely, amorphous silicon, copper indium diselenide, and cadmium telluride. It also indicates the several advantages of thin films. Various consumer products and power applications using thin film solar cells are also discussed. The increasing interest among the utilities for PV system applications is also elucidated. 29 refs., 8 figs., 3 tabs.

7152 **Starch synthesis and its regulation.** Preiss, J. (Michigan State Univ., East Lansing (USA)); Robinson, N.; Spilatro, S.;

McNamara, K. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

Although the regulatory mechanisms of starch synthesis appear to be similar for different cell types, it is not completely understood how these mechanisms are coordinated with the specialized physiology and chemistry of the different plant cell types. This report will thus present recent information on these aspects of starch synthesis.

7153 The degradation of transitory starch granules in chloroplasts. Beck, E. (Univ. of Bayreuth (West Germany)). pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

Considerable controversy concerning the mode of the degradation of this starch within the chloroplast is found in the literature, whereby the main discussion focuses on the question of whether hydrolysis by amylases, debranching enzyme and D-enzyme, or the energetically favorable phosphorolysis by phosphorylase represents the predominant pathway. Amylolytic activities have been observed in the chloroplasts of several species which were equivalent to, or even in excess of, that of phosphorylase, when both types of enzymic reactions were assayed under optimal conditions. In order to be able to comment on the respective importance of amylolysis and phosphorolysis, the following questions must be posed: which types of hydrolytic activities are present in the chloroplast, how are they regulated, and can the assimilatory starch granule serve as a substrate for both amylases and phosphorylase? With respect to the last question, more data on the structure and composition of the chloroplastic starch granule are required and, therefore, the first part of this paper is devoted to that subject. Finally, the question will be dealt with as to whether the chloroplast envelope provides a special translocating system for maltose and, if so, whether phosphorolytic starch breakdown is actually capable of preserving more energy than amylolytic degradation.

7154 Roles of pyrophosphate and fructose-2,6-bisphosphate in regulating plant sugar metabolism. Black, C.C. (Univ. of Georgia, Athens (USA)); Carnal, N.W.; Paz, N. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

The reciprocating flow of carbon between hexoses and trioses is a central process in all plant cells. Regulating the flow in either direction is poorly understood. Though they have known for decades that plants utilize sugars in almost countless ways; e.g. by synthesizing hexoses, carbon is directed into disaccharides, trisaccharides, or six carbon alcohols for translocation throughout a plant. In the plastid, trioses may be used to synthesize starch or, alternatively, trioses may flow out of the plastid to the cell cytoplasm for metabolic utilization as in amidation, oxidation, or hexose synthesis processes. Their understanding of carbon flow between hexoses and trioses currently is undergoing a vigorous re-examination because of two recent findings. First was the realization that pyrophosphate (PPi) is an energy source and phosphate donor for glycolytic carbon flow in plants and, second, the finding that a new hexose, fructose-2,6-bisphosphate (Fru-2,6-P_2) is present and active as a modulator of sugar metabolism. Here they will concentrate upon an interpretative model for the roles of PPi and Fru-2,6-P_2 in plant sugar metabolism.

7155 Characterization of fructose-1,6-bisphosphatase activity from Synechococcus leopoliensis. Latzko, E. (Botanisches Institut, Munster (West Germany)); Gerbling, K.; Steup, M. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

In summary, the authors have demonstrated the presence of two forms of FbPase, forms A and B, in the blue-green alga, Synechococcus leopoliensis. Form B was purified to homogeneity. This form exists in at least three different states (monomer, dimer, tetramer); only one of which is catalytically active. The interconversion of these states is outlined. It is not known whether a pool of the monomeric enzyme exists under native conditions or whether there is a reversible transition between the monomer and state I. However, the data clearly show that states I to III are readily interconvertible. Although the kinetics of the interconversion could not be followed in detail for technical reasons, the results indicated that the transitions from state I to III are completed in less than 30 min, even at 4°C. At 30°C, the entire sequence from I to III took place in ca. 10 min.

7156 Pyrophosphate and the glycolysis of sucrose in higher plants. Ap Rees, T. (Univ. of Cambridge (England)); Morrell, S.; Edwards, J.; Wilson, P.M.; Green, J.H. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

The authors adopted the following approach in an attempt to discover whether PPi served as an energy source by acting as a substrate for PFPase in plant glycolysis. First, they determined whether there was enough PPi present and whether the enzyme was generally distributed in nonphotosynthetic and nongluconeogenic tissues. Then they compared the maximum catalytic activity for PFPase with that of PFKase, and with the rate of respiration, during the differentiation of roots of 5 to 7-d-old seedlings of Pisum sativum L. cv. Kelvedon Wonder, and during the development of the club of the spadix of Arum maculatum L. This was done to discover if there was sufficient PFPase to mediate glycolysis, and if there was any relationship between FPFase and the rate of glycolysis. There is sufficient PPi in plant tissues for it to act as an energy source. There is evidence that PPi does act in this way during the metabolism of the sucrose that is delivered to developing embryos of pea and tubers of potato, where PPi is envisaged as driving UDP-glucose pyrophosphorylase towards glucose 1-phosphate. There may be a range of ways of producing the PPi needed to metabolize sucrose, but they point out that one possible source is PFPase. The key to this last question is the direction of the net flux catalyzed by PFPase in vivo. The presently available evidence does not distinguish between the view that the enzyme is a source of PPi and the hypothesis that it provides an entry into glycolysis in tissues characterized by marked biosynthesis.

7157 In vivo chlorophyll a fluorescence transients associated with changes in the CO_2 content of the gas-phase. Walker, D.A. (Univ. of Sheffield (England)); Sivak, M.N. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

The changes in chlorophyll *a* fluorescence which accompany changes in the gas phase from air to CO_2-free air are rapid, reproducible, and characteristic. Much of what is seen may be explained in terms of two main quenching mechanisms, q_Q and q_e, which are linked, respectively, to NADPH and ATP consumption in carbon assimilation. While much remains to be done before these interrelationships can be fully defined, it seems that, at the purely practical level, the gas transients have potential as a diagnostic probe. The present mannose feeding experiments were chosen to demonstrate that specific intervention in cytoplasmic events can also be rapidly reflected in gas-transient behavior. Clearly, this is the case, and with barley in particular, the gas-transient responses could be manipulated at will by alternating mannose feeding with Pi feeding. Before the nature of these changes can be properly explained, more work is needed, but the very fact that specific intervention in cytoplasmic events can bring about rapid and characteristic changes in fluorescence transients, adds to their belief that this type of diagnostic probe could play an increasingly useful role in the investigation of plant metabolism and its regulation.

7158 Fine control of sucrose synthesis by fructose-2,6-bisphosphate. Stitt, M. (Univ. of Gottingen (West Germany)). pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

The aim of this article is to outline how fructose-2,6-bisphosphate (Fru-2,6-P_2) is involved in the fine control of sucrose and starch synthesis in leaves, to consider how fine control may interact with other regulatory mechanisms, and to speculate about what long-term perspectives this control provides for manipulating photosynthetic metabolism.

7159 Compartmentation of glycolytic enzymes in plant cells. Dennis, D.T. (Queens Univ., Kingston, Ontario (Canada)); Hekman, W.E.; Thomson, A.; Ireland, R.J.; Botha, F.C.; Kruger, N.J. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

The major metabolic function of a particular plastid type is reflected in its constituent enzymes. Undoubtedly, the enzyme complement of the plastids within a particular tissue is a major factor in the control of metabolism in that tissue. This is clearly illustrated not only by the enzymes that are found in the leucoplasts in the endosperm of the castor oil seed, but also the difference in the enzymes found in bundle-sheath and mesophyll chloroplasts of C_4 plants. As yet, they have little idea about how the enzyme complement of such plastids is regulated. However, such information is essential if the differentiation of various plastid types is to be understood, and possibly manipulated.

7160 Metabolite levels, chloroplast envelope transport, and chloroplast metabolism. Portis, A.R. Jr. (Univ. of Illinois, Urbana (USA)); Ray, P.G.; Belknap, W.E. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

In any given metabolic pathway, the concentrations of various intermediates provide a picture of the flux through the pathway. These concentrations provide a rapid means of coordinating the fluxes through the various partial reactions of the pathway, such that they become equivalent under steady-state conditions. With given concentrations of the input and output intermediates, most pathways will spontaneously reach a steady-state condition due to this internal coordination. Therefore, it is of considerable interest to determine how the concentrations of intermediates of photosynthetic metabolism relate to the various possible photosynthetic fluxes. The authors currently have only limited information on how levels of various intermediates change with changing rates of photosynthesis and assimilate partitioning. The authors have presented theoretical calculation, experimental data obtained with isolated chloroplasts relevant to several aspects of the relationships between external metabolites, stromal metabolites, the rate of photosynthesis and assimilate partitioning. From such studies, they can begin to define the expected physiological range over which the metabolite ratios of Pi:PGA, Pi:DHAP, and PGA:DHAP could vary based on isolated chloroplast metabolism. These results are of particular importance because of current difficulties in accurately measuring cytoplasmic Pi levels in protoplast or intact leaf experiments.

7161 Enzyme assays at the single-cell level: Real-time, quantitative, and using natural substrate in solution. Outlaw, W.H. Jr. (Florida State Univ., Tallahassee (USA)); Springer, S.A.; Tarczynski, M.C. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

The purpose of this paper is to provide an overview of the entire set of methods for tissue manipulation. First, the authors briefly describe methods for tissue sampling, and then mass determination of single cells. Next, an actual procedure for assaying phosphoenopyruvate carboxylase in a single guard cell pair of Vicia faba is presented. Last, they discuss data interpretation. An appendix that provides answers to frequently asked questions follows the manuscript.

7162 Carboxylase response to CO_2 and O_2 in intact leaves of wheat and maize. Gustafson, S.W. (Univ. of Arizona, Tucson (USA)); Raynes, D.A.; Jensen, R.G. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

Little is known of the response of ribulose 1,5-bisphosphate (RuBP) carboxylase/oxygenase (Rubisco) in leaves exposed to a CO_2-free atmosphere. In order to better understand the relationship between O_2, RuBP levels, photorespiration, and Rubisco activation and their possible roles in regulating photoinhibition, experiments were conducted to measure the effect of exposing wheat and maize seedlings to either 1% O_2, or only N_2 for a 3-h period followed by 350 ppm CO_2 and 21% O_2 on net photosynthesis, RuBP levels and Rubisco activity.

7163 Chloroplasts at air levels of CO_2: Factors influencing CO_2-fixation. Seftor, R.E.B. (Univ. of Arizona, Tucson (USA)); Jensen, R.G. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

Research on CO_2 fixation using isolated chloroplasts is usually conducted at saturating levels of CO_2 in order to achieve the maximum rate of CO_2 fixation. This high ate of fixation, however, declines greatly after 10 to 20 min. The authors utilized an apparatus which permits chloroplasts to photosynthesize under CO_2 concentrations equivalent to air (10 μM aqueous equivalent) without depletion of the CO_2 in order to better understand photosynthesis and the reasons for the decline of CO_2 fixation. In particular, the relationship between photosynthetic CO_2 fixation under air levels of CO_2 and the activities of the ribulose 1,5-bisphosphate carboxylase/oxygenase (Rubisco) has been investigated.

7164 Regulation of resynthesis of the photosynthetic CO_2-acceptors: Feedback inhibition of transketolase. Knowles, F.C. (Univ. of California, San Diego, La Jolla (USA)). pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

In this study, the inhibition of transketolase is described and the implications of a feedback inhibition mechanism for regulation of resynthesis of CO_2-acceptor are discussed. Two methods were used to measure the activity of ribulose-5-P epimerase. A sampling procedure was carried out in which the quantity of xylulose-5-P formed in a given period of time was determined by spectrophotometric titration, being converted to sedoheptulose-7-P and glycerol-3-P. The quantity of xylulose-5-P present in the sample was calculated from the absorbance excursion at 338 nm due to oxidation of NADH by glycerol-3-P dehydrogenase. A coupled enzyme system was also used in which the rate of oxidation of NADH by glycerol-3-P dehydrogenase was monitored after establishing steady-state concentrations of xylulose-5-P, glyceraldehyde-3-P, and dihydroxyacetone-3-P by the action of ribulose-5-P epimerase, transketolase, and triose-phosphate isomerase.

7165 CO_2 photoassimilation of heat-stressed spinach chloroplasts. Cheefook Fu (Brandeis Univ., Waltham, MA (USA)); Gibbs, M. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant

Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

The effect of temperature on whole plant photosynthesis has received considerable attention. Clearly, investigation of temperature regulation of photosynthesis requires analysis at all levels of organization that may influence the assimilation of CO_2. In addition to the light-driven fixation of CO_2, temperature may affect photosynthetically-related processes such as stomatal closure and mitochondrial activities, resulting in equivocal conclusions. In the present study, the isolated, intact spinach chloroplast was used as a model system to determine the effect of temperature (from –15°C to +40°C) on CO_2 photoassimilation per se. The chloroplast system had the decided advantage that photosynthesis can be measured uncomplicated by respiration and other physiological phenomena of whole organisms. The results of their investigations with the spinach chloroplast demonstrate that photosynthetic response to temperatures lower than the optimum of 25°c is reversible. To the contrary, temperature higher than 25°c eventually results in an irreversible inactivation of a thylakoidal reaction.

7166 **Regulation and sucrose formation and movement.** Huber, S.C. (North Carolina State Univ., Raleigh (USA)); Kerr, P.S.; Kalt-Torres, W. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

Plant growth is ultimately dependent on photosynthesis as the source of reduced carbon. Processes that intervene between CO_2 assimilation in mature leaves and the growth of heterotropic plant parts include: (a) carbon partitioning between nontransport (e.g. starch) and transport forms (e.g. sucrose); (b) compartmentation of transport assimilates among pools; (c) phloem loading; (d) long distance translocation; and (e) phloem unloading and uptake/utilization in sink tissues. A comprehensive understanding of plant growth will require basic knowledge of these processes. Their objective is to identify biochemical mechanisms that may regulate sucrose formation and export, and to evaluate how metabolism in source and sink tissues may be coordinated.

7167 **Can development changes in tree architecture explain synchronized senescence in Metrosideros dieback forests?.** Gerrish, G. (Univ. of Hawaii, Manoa (USA)). pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The synchronized death of trees of Metrosideros polymorpha Gaud., the canopy dominant in Hawaiian montane rain forests, has been explained as the senescence of a single-generational cohort. The senescence process in these trees has not been described. It is my thesis that continual increase in size is the cause of this tree senescence, and that biochemical change is induced by correlative changes in shoot system morphology. Specifically, the authors hypothesis is that the decrease in the ratio of photosynthetic tissue to respiring tissue (P:R ratio) with growth, ontogeny, and standard development leads to carbon starvation. In this state, trees are more susceptible to stress and are less able to detoxify metabolic oxidants. The data are used in a tree growth simulation and imaging model. This model emphasizes the spatial organization of tree form and predicts the change in P:R ratio through growth and development. The tree growth model is being embedded in a stand-simulation model to test a second hypothesis that the P:R ratios of the trees in a stand are sufficiently uniform to explain the synchronized senescence observed in Metrosideros forests. The stand model accepts variable input for seeding pattern, growth rate distribution, and rules of competition for above-ground space. If a set of assumptions and input values, consistent with the known properties of Metrosideros forests, can be found that predicts a uniform P:R ratio in old age, the author will conclude that tree senescence can be explained as an extension of the processes of growth and development.

7168 **The influence of external pH on sucrose uptake and release in the maize scutellum.** Humphreys, T.E. (Univ. of Florida, Gainesville (USA)). pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

In this paper, the effects of external pH on sucrose uptake and release in maize scutellum slices are presented. The results indicate that both components of the chemical potential gradient of H^+ can drive sucrose uptake and that sucrose release is enhanced by a lower electrical potential gradient and by uptake of a compensating cation. The effects of external pH on sucrose release are puzzling.

7169 **Sucrose transport: Regulation and mechanism at the tonoplast.** Wyse, R. (Utah State Univ., Logan (USA)); Briskin, D.; Aloni, B. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

In most plants, sucrose plays a role similar to that of glucose in animals. Sucrose is the first free sugar formed as a result of photosynthetic carbon fixation and is the major form in which carbon is transported via the phloem throughout the plant. Therefore, sucrose is the source of glucose and fructose used for energy and the carbon source for the biosynthesis of all biomass. Sucrose also acts as both a transient and long-term storage carbohydrate. Thus, understanding sucrose transport and metabolism is central to understanding the regulation of assimilate partitioning.

7170 **Phloem-loading: A metaphysical phenomenon?.** Lucas, W.J. (Univ. of California, Davis (USA)). pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

An overview is presented the mechanism and pathway of sugar movement between the sites of production in the mesophyll cells and the sites of entry into the sieve elements. Topics of discussion include: retrieval of exogenous sugars; sucrose-H+ co-transport in the se-cc complex; electrophysiological studies on phloem cells; and the question of phloem loading.

7171 **Partitioning of sucrose into fructans in winter wheat stems.** Hendrix, J.E. (Colorado State Univ., Fort Collins (USA)). pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

This study focuses on the synthesis of nonstructural carbohydrates (NSC) in winter wheat stems. The initial effort was directed toward understanding the utilization of translocated sucrose by developing wheat grains on intact plants. The authors needed to learn whether they could introduce asymmetrically labeled sucrose into flag leaves and have that sucrose translocated in an unaltered form. They succeeded in doing that. A minor part of that effort involved supplying (^{14}C)glucose to the plants through flag leaves 10 d post-anthesis, a time of rapid grain growth. As expected, the label from the glucose became randomized between the two moieties of sucrose, at least near the radioactive front. However, nearer the supply point, the sucrose was more heavily labeled in its glucose moiety. Analogous data, though more difficult to interpret, were obtained when (^{14}C)(glucosyl)sucrose was supplied. They concluded that the stem was acting as a sink; and, in addition, that the fructose moiety of sucrose was being utilized selectively. They believe that new sucrose was being synthesized using the residual (^{14}C)glucose and fructose from a pool that lagged in its approach to isotropic equilibrium. An appropriate sink mechanism for the selective use of the fructose moiety of sucrose would be fructan synthesis.

7172 **Significance of carbon allocation to starch in growth of Beta vulgaris L.** Geiger, D.R. (Univ. of Dayton, OH (USA));

Jablonski, L.M.; Ploeger, B.J. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

This research was undertaken to test the proposed role of leaf carbohydrate reserves in regulating partitioning of carbon among sinks during adaptation of plant growth to shortened day length. First, a simple model was developed to illustrate the basic tenets of the hypothesis linking changes in storage of leaf starch to alteration of root:shoot ratio. Next, starch accumulation, net carbon exchange (NCE), leaf area, specific leaf area (SLA), root:shoot ratio, and total dry matter accumulation were measured over a several-week period in sugar beet plants maintained on 14-h days (LD) or adapting after transfer to 8-h days (SD). Finally, the data obtained were used with the model to generate a description of partitioning within plants adjusting to shortened day length. Feasibility of the model was evaluated by comparing values for various model parameters with plant growth measurements.

7173 **Other carbohydrates as translocated carbon sources: Acyclic polyols and photosynthetic carbon metabolism.** Loescher, W.H. (Washington State Univ., Pullman (USA)); Fellman, J.K.; Fox, T.C.; Davis, J.M.; Redgwell, R.J.; Kennedy, R.A. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

An attempt is made to measure photosynthesis and carbon metabolism in celery, Apium graveolens, a mannitol synthesizer. Celery is a convenient model for such work for several reasons, not the least of which is that it can readily be grown in conventional growth chambers. It also synthesizes, in addition to mannitol, both starch and sucrose, thus offering a convenient system for study of partitioning between those photosynthetic products. In addition, its growth habit provides a continuing supply of leaves at different developmental stages, a desirable characteristic for studies on sink-source transitions. Most importantly, when its exacting environmental requirements are met, the plant is capable of tremendous biomass production, up to 135 metric tons/ha. This alone indicates that its photosynthetic rates deserve close study. Their objectives has been to determine, through measurements of gas exchange and carbon metabolism, what may be photosynthetically unique in a plant that they already know to be highly productive of both biomass and polyol.

7174 **Interrelationships between photosynthetic carbon and nitrogen metabolism in mature soybean leaves and isolated leaf mesophyll cells.** Robinson, J.M. (Dept. of Agriculture, Beltsville, MD (USA)); Baysdorfer, C. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

This study has the purpose of examining, in mature soybean leaves and in intact mesophyll cells isolated from those leaves, the interrelationships between carbon and nitrogen photoassimilation. Specifically, the influence that NO_3^-, NO_2^-, and NH_4^+ exerts upon net CO_2 photoassimilation rate in leaves and isolated mesophyll leaf cells will be discussed in relationship to (1) competition between carbon and nitrogen photoassimilation for photolytically-derived reductant (reduced ferredoxin) or (2) how foliar nitrogen assimilation can stimulate photosynthetic carbon metabolism. Additionally, consideration will be given to the influence that inorganic nitrogen assimilation exerts upon foliar photosynthate partitioning between (a) the pentose phosphate reductive cycle, (b) the anaplerotic pathway, and (c) the synthesis of foliar starch, sucrose, and total amino acids.

7175 **Diurnal changes in carbon allocation: Morning.** Fondy, B.R. (Seton Hill College, Greensburg, PA (USA)); Geiger, D.R. pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

Recently, investigators have proposed a number of mechanisms for regulation of carbon allocation to sucrose and starch synthesis. These regulatory processes are thought to coordinate sucrose synthesis rate with net carbon export rate, to control storage of sucrose in the exporting leaf, and to moderate sucrose formation, allowing starch synthesis even in the presence of rapid synthesis and use of sucrose. It is important to characterize the mechanisms for controlling these critical physiological priorities under usual circumstances. In this work, they studied carbon allocation in exporting sugar beet leaves to identify priority uses for recent products of photosynthesis and to understand regulatory mechanisms operating at the beginning of the day.

7176 **Nonvascular transfer of assimilates in citrus juice tissues.** Koch, K.E. (Univ. of Florida, Gainesville (USA)). pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

Transfer of labeled assimilates through phloem-free areas and into sink tissues was examined in intact grapefruit (Citrus paradisi Macf.) and in rows of juice vesicles isolated with an attached vascular bundle. Entry of ^{14}C-photosynthates into phloem-free juice tissues was completed with 30 h in intact and isolated structures. Subsequent redistribution from hair-like vesicle stalks into juice vesicles, however, continued throughout the experiments. Localization of radioactivity suggests possible similarities in nonvascular transfer rates of both systems.

7177 **Regulation of carbohydrate partitioning.** Beevers, H. (Univ. of California, Santa Cruz (USA)). pp. 396 of Regulation of carbon partitioning in photosynthetic tissue. Heath, R.L.; Preiss, J. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1985). (CONF-8501124–: 8. annual symposium in plant physiology: regulation of carbon partitioning in photosynthetic tissue, Riverside, CA (USA), 11-12 Jan 1985).

The partitioning of carbohydrates in plants involves three components and their interaction: the supply of mobile sugars (principally sucrose) by the source leaves, transport to the sink, and processing or storage within the sink. The first requires an understanding of the carbon metabolism in photosynthetic cells and particularly of those reactions that control and maintain the steady-state level of sucrose in the cytosol in both light and darkness. The transport from photosynthetic cell to sink is itself composed of a series of steps. Each of these steps is a potentially-limiting constraint on the supply of sucrose to sinks, and they are all currently under active investigation.

7178 **27.6% efficiency (1 sun, air mass 1.5) monolithic $Al_{0.37}Ga_{0.63}As$/GaAs two-junction cascade solar cell with prismatic cover glass.** Chung, B. (Varian Research Center, Device Laboratory, Palo Alto, California 94303 (US)); Virshup, G.F.; Hikido, S.; Kaminar, N.R. *Applied Physics Letters (USA)*, 55(17): 1741-1743 (23 Oct 1989).

A 27.6% efficiency measured under 1 sun, air mass 1.5 illumination has been achieved in a two-terminal, monolithic two-junction cascade solar cell consisting of an $Al_{0.37}Ga_{0.63}As$ (E_g=1.93 eV) upper cell and a GaAs lower cell. The component cells were electrically connected together using a metal-interconnect contact fabricated during post-growth processing. Also, a prismatic cover glass was bonded to the front surface of the cascade structure to minimize the obscuration effect introduced by the grid lines and metal-interconnect contacts. As the cascade cell was operated under air mass 0 illumination, an efficiency of 23.0% was obtained. Both results represent the highest 1 sun efficiencies ever reported. The implications of achieving this high efficiency in a two-junction cascade solar cell for terrestrial and space applications are also described.

7179 **Nitrogen-dependent regulation of photosynthetic gene expression.** Plumley, F.G. (Univ. of Georgia, Athens (USA)); Schmidt, G.W. *Proceedings of the National Academy of Sciences of*

the United States of America (USA), 86(8): 2678-2682 (Apr 1989). DOE Contract FG09-84ER13188.

Nitrogen-limited Chlamydomonas reinhardtii is chlorotic and very deficient in chlorophyll a/b light-harvesting complexes (LHC). Rates of synthesis of photosynthetic proteins, but especially the LHC apoproteins, are reduced 10- to 40-fold. Moderately high levels of chloroplast transcripts accumulate in nitrogen-limited cells, and there is a correlation between chloroplast DNA levels and chloroplast mRNA abundance. In contrast, nuclear transcripts encoding LHCII and ribulose 1,5-bisphosphate carboxylase small subunits are markedly reduced. Thus, nitrogen availability affects chloroplast protein synthesis by inhibition of translocation and, to a lesser extent, chloroplast DNA amplification. Regulation of nuclear-encoded photosynthetic proteins by nitrogen is achieved through mechanisms affecting transcription and/or mRNA stability.

7180 **Structural and theoretical models of photosynthetic chromophores. Implications for redox, light absorption properties and vectorial electron flow.** Barkigia, K.M. (Brookhaven National Lab., Upton, NY (USA)); Chantranupong, L.; Smith, K.M.; Fajer, J. *Journal of the American Chemical Society (USA)*, 110(22): 7566-7567 (26 Oct 1988). DOE Contract AC02-76CH00016.

Single-crystal x-ray data for a homologous series of methyl bacteriopheophorbides d, derived from the antenna chlorophylls of the green photosynthetic bacterium Chorobium vibrioforme are presented. Crystallographically significant conformational variations are shown to be possible for the same chlorophyll skeleton. The possibility was considered that such conformational variations can affect the highest occupied and lowest unoccupied molecular orbital levels of the chlorophylls and thereby modulate their redox potentials and light adsorbing properties. This concept was tested by demonstrating that a sterically distorted porphyrin of known structure exhibited experimentally optical and redox properties in solution consonant with theory. 20 refs., 3 figs.

7181 **A carotenoid-diporphyrin-quinone model for photosynthetic mutistep electron and energy transfer.** Gust, D. (Arizona State Univ., Tempe (USA)); Moore, T.A.; Moore, A.L.; Makings, L.R.; Seely, G.R.; Ma, Xiaochun; Trier, T.T.; Gao, F. *Journal of the American Chemical Society (USA)*, 110(22): 7567-7569 (26 Oct 1988). DOE Contract FG02-86ER13620.

A four-component molecular device, which consists of two covalently linked porphyrins, one bearing a carotenoid polyene and the other a napthoquinone electron-acceptor, has been prepared to attempt to explain the electron-transfer strategy of photosynthesis. This tetrad was found to demonstrate singlet and triplet energy transfer behavior, which mimics photosynthetic antenna function by chlorophylls and carotenoids and carotenoid photoprotection from singlet oxygen damage. 27 refs., 1 fig.

1406 Photovoltaic Power Systems

Refer also to citation(s) 7113, 7634, 7635

7182 (IEIE–8801, pp. 151-154) **Technical problems concerning the implementation of distributed power sources in power system.** Tsukamoto, Osami (Yokohama National Univ. (Japan)). Institute of Electrical and Information Engineers (Japan). 5 Sep 1988. (In Japanese). In *1988 joint conventional record of Institutes of Electrical and Information Engineers, Japan (Part 1)*. Available from NTIS (US Sales Only), PC A09/MF A01.

This paper comprehensively discusses technical problems and themes which will be involved when distributed power sources which are attracting attention, such as fuel cells, photovoltaic power generation equipment, and wind power generation equipment, are linked to existing power systems. It also discusses the influence of such distributed power sources on power systems. Subjects covered are as follows: (1) Characteristics of each distributed power source and technical problems involved in its development. (2) Problems concerning the implementation of distributed power sources in power systems – the themes discussed in detail here are problems concerning start and stop, steady operation, accidents, and maintenance. In particular, the discussion of accidents deals with emergency measures which should be adopted for power systems when short-circuit accidents, grounding accidents, overvoltage, low voltage, or other accidents occur. (3) Studies in Japan on the implementation of distributed power sources in power systems are reviewed. (4) Problems to be studied in the future. 2 references.

7183 (JESE–8801, pp. 137-140) **Islanding phenomenon prevention technology of small-scale dispersed PV systems.** Takigawa, Kiyoshi (Central Research Inst. of Electric Power Industry, Tokyo (Japan)); Kobayashi, Hirotake; Takeda, Yukihiro. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference*. Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Islanding phenomenon prevention system must be established for quick and positive suspension of the operation of photovoltaic power generation system in case of power failure in distribution lines, and the results of a demonstration test made at the Rokko Island 200kW PV test facility was evaluated and studied. The 100 PV power generation systems were equipped with detection devices for excess or deficiency voltage at connecting points and for proper frequency, as a minimum function for the prevention of islanding phenomenon. All of the 100 inverters are of self-excited type, and classified into voltage control type and current control type. Island phenomenon was not observed, regardless of the conditions of the amounts of power generation and load, when only the current control type system was operated, proving that the current control system to be effective for the prevention of islanding phenomenon. Other new protective methods such as frequency bias system and others must be studied and added to the voltage control type system. 2 refs., 5 figs.

7184 (JSES–8801, pp. 37-40) **Estimation of photovoltaic power generation system by the simulation.** Segawa, Yosuke (Doshisha Univ., Kyoto (Japan)); Fujita, Yoshikazu; Kida, Junzo; Ishihara, Yoshiyuki; Todaka, Toshiyuki. Japan Solar Energy Society, Tokyo (Japan). 1988. (In Japanese). (CONF-881293–: JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference*. Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

The year load factor which indicates the change in the power demand by season and time zone tends to lower year by year. The solution for this problem is the development of a low cost system, and 2 photovoltaic power generation system are introduced to study their effectiveness and economical advantage. As regards photovoltaic power generation system for factory, one with a connecting facility to the commercial power source and the other having a storage equipment for nighttime electric power were studied. The result of the study on the yearlong simulation by these 2 systems from the viewpoints of load leveling and stable power supply indicates that minimum unit cost of power generation energy can be achieved when the rate of power generation amount in normal load is adopted as the peak load. In the case of power generation system with battery, it was learned that the effective generated power is increased by ingenious operational pattern. The photovoltaic power generation with a nighttime charging equipment was found to decrease the contracted electric power as well as the electricity rate. 3 refs., 7 figs., 3 tabs.

7185 (JSES–8801, pp. 41-44) **Capability of photovoltaic power generation system.** Takahashi, Masahide (Kabushiki Kaisha Shikoku Sogo Kenkyu Sho (Japan)); Kawasaki, Kensuke. Japan Solar Energy Society, Tokyo (Japan). 1988. (In Japanese). (CONF-881293–: JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference*. Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

In the study on photovoltaic power generation, analysis have been made for the amount of power generation, but the capability for power generation has not been well analyzed. Under the situation, the relationship of equipment capacity and power generating capability was analyzed. Power generation capability is hard to learn because it varies with the output power of the solar cell which is instantaneously influenced by the variation of solar radiation amount and the condition of the battery at that time. It is also affected by the combining method of solar cells and batteries. To cope with this

problem, a simulation program was prepared to analyze the relationship between the equipment capacity and power generation capability by simulation analysis using actually measured amount of solar radiation. The result of a test operation was compared with the result of the simulated calculation. As a result, the accuracy of the simulation program was proved to be satisfactory for the analysis of power generating capability of the system. This method enables an advance analysis of power generation if data on the amount of solar radiation is available, and is considered to be one of the best methods for the determination of equipment capacity and others. 4 figs.

7186 (JSES–8801, pp. 45-48) **On the methodology of estimating ineffective sunshine hours for a solar water pumping system without storage battery.** Yamayoshi, Takeshi (Kyocera Corp., Kyoto (Japan)); Yoshimi, Tetsuo; Umezawa, Tasuhiko; Takeuchi, Sumiko. Japan Solar Energy Society, Tokyo (Japan). 1988. (In Japanese). (CONF-881293–: JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

The solar radiation data collected at the Solar Energy Center at Sakura, Chiba were statistically processed, and formulas were derived which express the relationship among the day amount of solar irradiance, mean daily strength of solar irradiance, and their variation, and a methodology of estimating the ratio of ineffective sunshine hours to possible duration of sunshine was developed. The intensities of solar radiation (X) were selected for $X \leq 10$, 20, 30, 40 and 50 [mW/cm^2]. The computed values (hour) were integrated every day to establish a monthly unit. The ratio of measured value of the integrated monthly hours to estimated value of the integrated monthly hours was used for the evaluation. The result acquired was compared with the solar irradiation data measured at Kagoshima to confirm the reliability of this methodology. The relation of the amount of the integrated daily solar radiation and daily standard deviation showed nearly similar tendency in both cases. Maximum rate of 1.2 was obtained when $X \leq 10$ [mW/cm^2]. The result showed that this methodology of estimation can be quite satisfactorily used at Sakura as well as at Kagoshima. 4 refs., 5 figs., 1 tab.

7187 (JSES–8801, pp. 49-52) **Evaluation of water volume of photovoltaic pumping system by tracking array.** Kondo, Shigeki (Kyocera Corp., Kyoto (Japan)); Hara, Tetsuo. Japan Solar Energy Society, Tokyo (Japan). 1988. (In Japanese). (CONF-881293–: JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Research and development are being carried on, using a single-axis non-concentrated tracking photovoltaic power generation system, to increase the amount of energy generation and for stable control of power supply. A report is made on the increase in the water volume pumped up when this system is applied to a solar pump system equipped with no storage battery. To compare the water volume pumped up by a tracking array with that pumped up by a fixed array under the same condition, an array simulator was used which simulates the solar cell output power, for the total head of the same pump. The output powers of the tracking frame and fixed frame are supplied to a submergible motor pump through a VVVF inverter. Approximately higher than 55 Hz frequency was required in this experiment because the total head was set to 50 m. The rise time of the increase in the acquired energy is fast in the case of the tracking arrays, and water can be pumped up even at the time when fixed arrays can not be used for the purpose. This resulted in larger increase in the volume of pumped up water as compared with the increase in the generated power. 3 refs., 8 figs., 4 tabs.

7188 (JSES–8801, pp. 53-56) **Characteristics of short circuit at redox flow battery.** Tsuba, Izumi (Electrotechnical Lab., Tsukuba (Japan)); Kurokawa, Hirosuke; Nozaki, ken; Akai, Yuichi. Japan Solar Energy Society, Tokyo (Japan). 1988. (In Japanese). (CONF-881293–: JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

As a method of solving problems related with the lead storage battery used in current photovoltaic power generating system, introduction of the redox flow battery to the system is proposed, and experiments have been carried out. The advantages of the redox flow battery are the possibility of charging and discharging voltage switching by tap changing, no occurrence of self-discharge in principle, etc. To study the problem on short circuit protection for the entire battery, short circuit measurements were performed for the period from several μ seconds to 1 second. The short circuit current has the first peak current region (approximately 1 m after short circuiting), flat region (from about 1 m to 100 m), and slow time constant decay region (from 100 m to about 1). The apparent internal impedance after 100 m is approximately 2 Ω per cell, which is larger than the measured result of the internal resistance (1 Ω/cm^2). No degradation in the electrical performance of the battery was observed even after the short circuit experiment. 4 refs., 7 figs., 1 tab.

7189 (JSES–8801, pp. 57-60) **Non-polluting electric vehicle seeking energy source in solar battery (2).** Fujinaka, Masaharu (Tokyo Denki Univ., Tokyo (Japan)). Japan Solar Energy Society, Tokyo (Japan). 1988. (In Japanese). (CONF-881293–: JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Solar cells are set on the roof or a house whose output power is used to charge the secondary battery installed on an electric vehicle, and latest solar cells are mounted on the roof of the vehicle. Driving tests of the electric vehicle which is charged by these two solar cell systems have been carried on. The distance covered was roughly proportional to the conditions of the amount of solar radiation. Fortunately no damage from freezing was experienced with the cells for the past several years because the tests were carried out in the suburbs of Tokyo. Since the experiment started at the end of August, 1988, about 4000 km was covered in one and a half years. The solar cells can generate electricity by the airlight to run the electric vehicle even on rainy or clouded days. In the past 2 years and a half, no gasoline was consumed to run the vehicle for the total distance of 7500 km. The maximum distance which can be covered by one time charging is approximately 100 km for an average electric vehicle installed with a secondary battery of 96 V and 150 Ah, which may be extended to 300 km if an ideal car body is designed. 8 refs., 1 fig.

7190 (JSES–8801, pp. 61-64) **Effective utilization of solar energy applied to so-called aging society.** Ano, Tsunetomo. Japan Solar Energy Society, Tokyo (Japan). 1988. (In Japanese). (CONF-881293–: JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

The result of the experiments on solar heat application and a concrete way of promoting practical application of photovoltaic power generation are described. From the standpoint of effective use of solar energy, snow-melting pipes which are considered to be idle facilities were used as solar heat collectors to supply hot water to homes. The acquired year mean energy can be considered to exceed 80 kW/m^2. The amount can be converted to over 9 - 10 l/m^2 of kerosene, i.e. 90 - 100 l/m^2 in ten years, when the efficiency of the boiler is taken into consideration. Overall running and maintenance costs of various facilities were studied based on the result of the 10 year experiments, and the system proved to be excellent. Lastly, a proposal for practical application of photovoltaic power generation is submitted. 10 refs., 2 figs., 2 tabs.

7191 (JSES–8801, pp. 133-136) **Generation characteristics of small scale residential PV systems.** Kobayashi, Hirotake (Central Research Inst. of Electric Power Industry, Tokyo (Japan)); Takigawa, Kiyoshi; Takeda, Yukihiro. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Under contract awarded by the NEDO, long term power generation characteristics and stability of small scale residential PV

systems are being evaluated by a continuous test operation using the Rokko Island 200kW photovoltaic power generation facility. Stable operation of every system was confirmed, but the overall power generation efficiency of the system was found to be lower than the designed value. Field experiments were conducted, therefore, to clarify the cause of the lower generation efficiency by the measurement and evaluation of the matching of the output characteristics of solar array with the inverter DC operation voltage. It was found that the causes were the decrease in the power generation characteristics of the solar cell array due to characteristic variation of the solar cell modules and the mismatching loss of the inverter DC operating voltage. As a result of the experiments, it became clear that the loss and variation caused by the characteristic fluctuation of solar cell modules must be taken into consideration in the design of solar cell module structure and inverter DC operating voltage for solar cell arrays. 2 refs., 5 figs.

7192 (SAND–89-2134C) **Sizing and selection of batteries for stand-alone photovoltaic systems.** Chapman, R.N.; Chamberlin, J.L. Sandia National Labs., Albuquerque, NM (USA). 1990. 14p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-900138–3: 5. annual battery conference on applications and advances, Long Beach, CA (USA), 16-18 Jan 1990). Order Number DE90002990. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The process used to design battery subsystems for stand-alone photovoltaic systems is presented in two steps; sizing and selection. The sizing step gives the raw usable capacity required for the application. A nomographic technique and a computer simulation technique for sizing are reviewed. The second step, which is presented in a worksheet format, gives the final battery capacity and its configuration based on the characteristics of the selected cell and the working environment. A design example is given to illustrate the sizing and selection processes. 6 refs., 4 figs.

1407 Solar Thermal Power Systems

Refer also to citation(s) 7181, 7193, 7194, 8201

7193 **Electric utility views of the solar power tower.** Holmes, J.T. (Sandia National Labs., Div. 6226, Albuquerque, NM (US)). vp of The 8th Miami international conference on alternative energy sources. Volume 1-2 (Condensed Papers). Vezioglu, T.N. Clean Energy Research Inst. University of Miami, Coral Gables, FL (1988). DOE Contract AC04-76DP00789. (CONF-871204–: 8. Miami international conference on alternative energy sources, Miami Beach, FL (USA), 14-16 Dec 1987).

Two electric utility, architect engineer, and hardware design and manufacturer teams recently completed year-long independent studies to determine the best state-of-the-art configuration for future solar central receiver (power tower) electric plants. This is the first step along the path to make the power tower a viable option for the future generating needs of the utilities. Their work concentrated on evaluating a number of system and subsystem options and developing the most cost effective integrated power plant. The key issues addressed by the teams were: plant size, capacity factor, solar multiple and energy storage size, heat transport fluids, solar collector (heliostat), solar receiver configuration, and fossil solar hybridization.

1408 Ocean Energy Systems

7194 (CONF-8911151–1) **Conceptual design analysis for hybrid-cycle OTEC plants for co-production of electric power and desalinated water.** Rabas, T.; Panchal, C.; Genens, L. Argonne National Lab., IL (USA). [1989]. 11p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract W-31109-ENG-38. From International conference on ocean energy recovery; Honolulu, HI (USA); 28-30 Nov 1989. Order Number DE90003551. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Hybrid-cycle OTEC power plants are shown to be potentially the most flexible and cost effective in obtaining any specific mix of electrical power and desalinated water. This paper describes two particular hybrid configurations, one achieves maximum power production and the other maximum water production for a given cold sea-water flow rate and pipe size. When power is the desired commodity and desalinated water is the by-product, the most effective configuration is the conventional hybrid cycle. When only water production is required, the desired configuration combines a multistage flash evaporator and a closed-cycle power OTEC plant, the latter generates the power to run the support equipment with no net or minimal power generation. 13 refs., 4 figs., 1 tab.

7195 (ETDE-mf–9761939) **Salinity gradient power plants.** Reali, M. Ente Nazionale per l'Energia Elettrica, Milan (Italy). May 1986. 17p. (In Italian). Order Number DE89761939. Available from NTIS (US Sales Only), PC A03/MF A01.

This paper reviews salinity gradient power plant technology. With reference to present research and applications, and with the aid of several schematic diagrams, a variety of aspects are covered - thermodynamic equilibrium, semipermeable membranes, conversion plant design and closed cycle electro-osmotic systems used in conjunction with solar thermal power systems.

1409 Solar Thermal Utilization

Refer also to citation(s) 7143, 7189, 7783, 7787, 7788, 7789, 7790, 7792, 7797

7196 (CMHC–87E53) **Energy-efficient passive solar house designs for Canada.** Canada Mortgage and Housing Corp., Ottawa, ON (Canada). 3 Nov 1987. 45p. (MICROLOG–89-04402). Available from PC Canada Mortgage and Housing Corporation, Annex Bldg., 628 Montreal Rd., Ottawa, ON, CAN K1A 0P7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

The principles of passive solar design for Canadian houses are introduced. Details are provided on the selection, sizing, and location of windows (solar collectors); design for distribution of heat throughout the house; thermal storage; and integration of the passive solar features and other energy conservation measures with the aid of performance analysis tools. 15 figs.

7197 (CONF-8609473–1) **Passive solar residential buildings in Italy: Results of a national survey.** Funaro, G.; D'Errico, E.; Del Bufalo, S. ENEA, Casaccia (Italy). Dipt. Fonti Alternative Rinnovabili e Risparmio Energetico. Sep 1986. 7p. (In Italian). From PLEA '86 Pecs conference; No City Given (Hungary); Sep 1986. Order Number DE89761960. Available from NTIS (US Sales Only), PC A02/MF A01.

Paper presented at PLEA 86 Pecs (Hungary, Sep 1986).

Residential passive solar buildings in Italy account for more than 78% of the total number (of passive solar buildings), 14% of which are detached houses and 64% are multi-family buildings, with a total volume of 450.000 cubic meters, or more than 1.700 apartments. The paper presents the final results of an exhaustive survey conducted by the Italian Commission for Nuclear and Alternative Energy Sources (ENEA) on passive solar architecture in Italy. The paper focuses on the architectural and technical problems related to the use of passive solar features in rather large residential buildings, chosen among the most significant Italian passive solar building projects. The technical aspects of some of the most interesting buildings using passive solar technologies for space heating, in addition to solar collectors for domestic hot water, are described in detail.

7198 (EUR–11274) **The Peterborough solar project: The design, realization, monitoring and assessment of a terrace of three solar houses near Peterborough, United Kingdom: Demonstration project: Final report.** Martin, C. (Polytechnic of Central London (UK)); Littler, J. Commission of the European Communities, Luxembourg (Luxembourg). Directorate General Telecommunications, Information Industries and Innovation; Polytechnic of Central London (UK). c 1988. 67p. Sponsored by Commission of the European Communities. SE/216/81/UK. Available from NTIS (US Sales Only), PC A04/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg ECU 7.50.

This project has demonstrated the technical feasibility of active solar air systems with smart controls in domestic buildings, and indicates that although not economic at present, a system can be

envisaged which has a materials cost of around $2000. Based on the materials cost alone, such a system is competitive with peak rate electricity at today's prices. Further refinement is needed before the total system cost can be justified. Such refinement might mean removing the heat storage facility if the system were to be installed in a building with a daytime load, or might involve alternative collector materials. In general, the nature of the building trade will mean that further demonstration projects will be needed before such systems will be built in quantity.

7199 (EUR–11644) **Solar collector plant at the Badesoen swimming-pool: Demonstration project: Final report.** Commission of the European Communities, Luxembourg (Luxembourg). Directorate General Telecommunications, Information Industries and Innovation; Albertslund Kommune (Denmark). c 1988. 70p. Sponsored by Commission of the European Communities. SE/P/23/81/DK. Available from NTIS (US Sales Only), PC A04/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg ECU 6.25.

The report treats of a low temperature solar collector plant for an outdoor swimming pool in Albertslund Municipality at Copenhagen, which is constructed as an unglazed, non-insulated polyolefin solar collector with direct circulation of the pool water. The plant has comprehensive equipment for measuring temperatures and energy flow, which data is automatically compiled and processed in a central control and monitoring system. The report gives output and efficiency figures as well as cost and profit as compared with estimated figures.

7200 (JSES–8801, pp. 109-112) **Thermodynamic assessment of performance of thermal solar systems.** Nakanishi, Shigeyasu (Himeji Inst. of Tech., Himeji (Japan)); Murai, Kazuhiro; Kawashima, Yosuke; Enomoto, Tomoyuki. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference*. Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Particularity as an energy must by considered for heat in the evaluation of the performance of solar utilization systems. Heat can be properly evaluated only when its quality, namely the thermal level, is specified in addition to its amount of energy. In this study, energy analysis was carried out for a solar system coupled with a heat pump unit. For the evaluation of a system coupled with a heat pump unit, a gain factor was introduced as a new performance index. It is defined as a ratio to the actual COP(coefficient of performance) of the maximum COP obtained by a reversible heat pump without thermodynamic loss and entropy increase. As the result of the introduction of conversion efficiency defined by the ratio of the energy gain per day of the system to the total solar radiation energy incidence on the collectors as the index to evaluate the performance of a thermal solar system, the upper limit of the gain from system was found to be given by the maximum conversion efficiency of a simple heat collecting system. 3 refs., 8 figs.

7201 (JSES–8801, pp. 185-188) **Performance tests of upward and downward heating-system multiple-effect solar heat distillers.** Sato, Nobuya (Keio Univ., Tokyo (Japan)); Watabe, Koichi. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference*. Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Among seawater desalination systems, the multiple-effect solar heat distiller utilizes solar energy which lasts forever, uses condensation latent heat repeatedly, and utilizes heat energy effectively; thereby, it is expected that its distilling performance is greatly improved from that of the existing single-stage distiller. There are the upward heating system and the downward heating system in the heating systems of the multiple-effect distillers and each system has its own advantage. In this study, concerning the upward heating system, outdoor experiments utilizing the sunlight were conducted for a six-stage effect type, and concerning the downward heating system, indoor experiments were conducted by heating a two-stage effect type distiller with an electric heater. As a result, with regard to the upward heating system, it showed distilling performance higher by 2-3 times than that of the single-stage distiller in outdoors for a long period, but its unsteadiness could not be ignored. With regard to the downward heating system, its performance was greatly improved in comparison with that of the single-stage type, its distillation yield increased considerably as the given heat flux increased and the effectiveness of its usage in combination with an inverted flat plate heat collector was recognized. 6 refs., 9 figs.

7202 (NAL-TR–992) **LH_2/LO_2 rocket engine with solar energy.** Kanda, Takeshi; Wakamatsu, Yoshio; Kanmuri, Akio. National Aerospace Lab., Chofu, Tokyo (Japan). Aug 1988. 16p. (In Japanese). Order Number DE89910187. Available from NTIS (US Sales Only), PC A03/MF A01.

LH_2/LO_2 rocket engine was studied, in which a solar heat exchanger with a concave mirror was incorporated within an expander cycle. It was assumed that hydrogen was fed from a pump to a combustion chamber through such processes as regenerative cooling of the combustion chamber and nozzle skirt, heat exchange at a solar heat absorber, and driving of a turbine. Characteristics were calculated for the engines of 5MPa and 1MPa in combustion chamber pressure. As a result, the additional solar heat supply allowed a higher specific impulse, lower engine pressure level at the same combustion chamber pressure, and greater payload. The heat absorber with a heat box allowed a smaller concave mirror and greater payload than that with a heat panel only. Remarkably higher specific impulse was achieved by the optimal mixing ratio, and in that case, lower combustion chamber pressure brought about higher efficiency. Furthermore, the solar heat exchanger without a converging mirror was also studied. 17 refs., 23 figs., 1 tab.

7203 (NEI-DK–239) **Report on measurements on a smaller self-circulating solar collector system in Thailand.** Genborg, T.; Nielsen, J.E. Teknologisk Inst., Taastrup (Denmark). Proevestationen for Solvarmeanlaeg. Jul 1988. 39p. (In Danish). Order Number DE90728142. Available from NTIS (US Sales Only), PC A03/MF A01.

Measurements taken on a smaller self-circulating solar heating system in Bangkok over a period of 6 days. The system comprised a solar collector and an isolated storage tank with full control over the drawing of the water supply. (AB).

7204 (NEI-DK–242) **User manual and documentation for FJERNSOL: A PC program for calculation of solar heating plants in district heating networks.** Nielsen, J.E. Teknologisk Inst., Taastrup (Denmark). Proevestationen for Solvarmeanlaeg. 1989. 110p. (In Danish). Contract TR-87.084. Order Number DE90728163. Available from NTIS (US Sales Only), PC A06/MF A01.

Documentation for FJERNSOL is presented. FJERNSOL is a PC program which is able to simulate the interaction between solar heating systems, district heating networks and energy consumption. The program can be used to calculate three different applications of solar heat in connection with a district heating network: (1) Solar heating system coupled to the district heating's recirculation network. (2) Solar heating system for summer supply of a small part of the district heating network. (3) Reduction of heat losses from the piping system during the summer period and alternative supply from individual solar heating systems. (BN).

7205 (S–89-04277) **Evaluation of the payback for the solar DHW [domstic hot water] system at Craigwiel Gardens apartments.** Solcan Ltd., London, ON (Canada). 31 Mar 1988. 12p. (MICROLOG–89-04277). Available from PC Canada Mortgage and Housing Corporation, Annex Bldg., 628 Montreal Rd., Ottawa, ON, CAN K1A 0P7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

Solcan Ltd. has designed and installed a solar hot water system on the Craigwiel Gardens Senior Citizens Apartments in Ailsa Craig, Ontario. The solar water heating system was designed to supplement the building's domestic hot water requirements, which are normally supplied by electricity. The solar system incorporates 16 Solcan collectors, comprising an area of 35.2 m^2, with a storage capacity of 820 litres. The system, system control and system monitoring are described. Statistics of water and electricity use monthly are given for the years 1985-1987. The total hot water used in the building was, on the average, 856,000 l/y, or less than 1/3 of what

was predicted. The energy load predicted by the computer code WATSUN was 94.5 GJ. The actual values from March 1986 to February 1987 and from March 1987 to February 1988 were 46.3 and 48.57 GJ. The system currently produces 1.3 GJ/y.m^2 but, if optimized, could produce between 2.0 and 2.6 GJ/y.m^2; therefore, the solar gain is about 1/2 of what was predicted. It means about 47 GJ/y or 13,100 kWh/y, or $660/y at a cost of 5 cents/kWh; such a saving is modest at present, but will increase with more hot water demand. 4 figs., 1 tab.

7206 (SU–CE-02826) **Monitoring and performance evaluation of attached sunspaces.** Saskatchewan Univ., Saskatoon, SK (Canada). Jul 1988. 20p. (CE–02826). Available from Energy, Mines and Resources Canada, Communications Branch, 580 Booth St., Ottawa, ON, CAN K1A 0E4. Prices: PRICES UPON REQUEST.

The heating and cooling energy requirements of four sunspaces representing a variety of construction types and orientations are presented. The results are based on extensive temperature and air infiltration monitoring of the four sunspaces, which are located in Saskatoon, Saskatchewan. A computer thermal simulation model validated against the measured data was used to predict the performance of the sunspaces at other representative locations: Vancouver, Toronto, and Fredericton. As well, several operating strategies to increase sunspace thermal efficiency were examined.

7207 **U.S. participation in international atrium research.** Gordon, H.T. (Lawrence Berkeley Lab., CA (USA)); Anderson, D.L.; Andersson, B. pp. 488 of Proceedings of Solar 89, the 14th national passive solar conference. American Solar Energy Society, New York, NY (1989). (CONF-8906165–: 14. national passive solar conference, Denver, CO (USA), 19-22 Jun 1989).

The United States, with funding by the DOE Office of Solar Heat Technologies, is participating in international atrium research activities under the following agreements: Annex XI of the International Energy Agency, Solar Heating and Cooling Implementing Agreement, for Passive Solar Commercial Buildings, and the US/UK Bilateral Agreement for Collaborative Research, instituted in October 1984. US involvement in these efforts reflects the fact that atria are perhaps the least understood of the passive commercial strategies, yet have become very popular, and often energy-intensive, additions to US commercial buildings. This paper describes activities to date and research agendas being developed under each agreement. Primary focus is on atrium terminology being developed as part of the IEA Annex.

7208 **Potential benefits of distributed PCM thermal storage.** Neeper, D.A. (Advanced Engineering Technology Group, MS J576, Los Alamos National Lab., Los Alamos, NM (US)). pp. 488 of Proceedings of Solar 89, the 14th national passive solar conference. American Solar Energy Society, New York, NY (1989). (CONF-8906165–: 14. national passive solar conference, Denver, CO (USA), 19-22 Jun 1989).

This report examines the benefits of passive thermal storage by means of phase change material (PCM) distributed throughout the wall and ceiling surfaces of a building, as would occur if the wallboard were impregnated with PCM. Surface heat transfer is expected to be adequate for thermal storage capacity up to 40-Bu/ft^2 of surface area. Sums of daily energy balances during the heating season indicate that use of PCM-impregnated wallboard with a 40-Btu/ft^2 capacity would provide adequate storage for direct gain systems with the largest practical window area in Denver, Boston, and Fort Wroth. It is shown that distributed PCM thermal storage offers the opportunity to obtain several ton-hours of ventilative cooling per night throughout much of the U.S. during July.

7209 **PSIC and the builder guidelines.** Szoke, S.S. (National Concrete Masonry Association, Herndon, VA (USA)). pp. 488 of Proceedings of Solar 89, the 14th national passive solar conference. American Solar Energy Society, New York, NY (1989). (CONF-8906165–: 14. national passive solar conference, Denver, CO (USA), 19-22 Jun 1989).

The Passive Solar Industries Council (PSIC) was founded in September, 1981 by some of the leading organizations in the building industry. PSIC encourages participation from independent builders, architects and other building professionals. Passive solar structures involve the combination of materials produced by diversified competitive industries. Combinations and tradeoffs are required of energy conservation solar collection, heat storage, control methods and heat recovery with few or no active parts. Good passive solar starts at the design phase and usually requires some modification of typical construction practice. Together these diversified groups create more interest in passive solar through non-proprietory programs and activities. The interest in high-quality energy efficient design prevail and the members of the Passive Solar Industries Council resolved or ignored the competitive differences. In the PSIC forum they cooperatively encourage the required changes in construction practices; acting as the catalyst to implement and promote these changes.

1410 Solar Collectors and Concentrators

7210 (DTH-LV-MEDD–204) **Superinsulating transparent cover.** Energiministeriets Solvarmeprogram. Rapport, 49. Ingerslev Jensen, K. Danmarks Tekniske Hoejskole, Lyngby (Denmark). Lab. for Varmeisolering. Jul 1989. 115p. (In Danish). Order Number DE90728161. Available from NTIS (US Sales Only), PC A06/MF A01.

EFP-87.

This report deals with the development of a new transparent insulating material called monolithic silica aerogel. The heat insulation is very high especially if the material is kept under low pressure. There are quite a few formulas for determining the heat transfer through the monolithic silica aerogel. Because of the properties of the material, it must be enclosed in a sort of thermopane, and in that case the edge of the thermopane may appear as a very serious cold bridge, but an analytic solution has been developed for determining the influence of the cold bridge. Demands and wishes for the cover and the expected problems are discussed. Special interest has been given to maintaining low pressure in the cover and to the design of the edges as far as air tightness and cold bridges are concerned. Calculations indicate a possibility for a satisfactory solution based on an organic joint filler and a thin metal foil. The cover is expected to have a heat loss coefficient of 0.5 Wm-2K-1 and a solar transmittance up to 75%. Various solutions have been discussed and on that background some prototypes have been made as well as tests of how to evacuate them. An estimate of the annual output when using this specific cover for solar collectors and solar walls has been made on the basis of computer simulations and comparisons have also been made with the results for other covers. Calculations have shown considerable improvements, up to about 25% and 50%. Finally an estimate of the price of all the elements used for the construction of the cover in question has been given. (author).

7211 (JSES–8801, pp. 141-144) **Durability test on selective absorbers. (Part 2).** Santo, Mutsuo (Government Industrial Research Inst., Nagoya (Japan)). Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

To study the durability of selective absorber materials, an accelerated durability test by heat load and the real time durability test were carried out in which the heat collection materials are exposed to solar radiation in the condition similar to that of the actual heat collector. Selective plates of chromate treated colored stainless steel and anodic oxidized colored alumite with and without protective coating of acrylic film were used for the test. The specimens were subjected to the accelerated durability test at 400°C - 140°C test tank temperatures and the absolute humidity of less than 20 mm Hg H_2O to study the change with time of the emittance and solar reflectance at the respective temperature. Emittance and reflectance of the plates with acrylic coating showed complicated variations. The reflectance of the colored stainless steel plates only exhibited the increase far exceeding the error by the measuring instrument, and others showed little variation. 6 figs.

7212 (JSES–8801, pp. 145-148) **Accelerated aging testing of black chrome coating under heat loads and degradation mechanism.** Tanemura, Sakae (Government Industrial Research

Inst., Nagoya (Japan)); Yoshimura, Kazuki; Taga, Kazuo; Kohira, Takashi; Ishida, Masaharu. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Accelerated aging tests of selective absorbing coating materials were carried out to quantify the change in optical properties, and a numerical model for a simple way to describe by parameters the relationship between the acceleration time and degradation of the functions was evaluated. Two kinds of black Cr coatings and Ni pigmented anodized Al coatings were chosen as the specimens. The temperatures of 280, 400, and 500°C C were employed as heat loads with applied aging times of 3, 50, 100 and 1000 hours, 3, 6, 10, 20, 50 and 500 hours, and 1, 3, 6, 10 and 20 hours respectively. The result of the experiments suggest that Arrhenius and Eyring equations can not be applied adequately. The diffusion to the surface of coatings and crystallization of Ni, diffusion of C, Cr and O to the inside of coatings and to Ni layer were obvious. These degradation mechanism is considered to be the reason for the inappropriateness of the above models. 7 refs., 4 figs.

7213 (JSES–8801, pp. 149-152) **Accelerated aging testing of nickel pigmented anodized aluminium coating under heat loads and degradation mechanism.** Tanemura, Sakae (Government Industrial Research Inst., Nagoya (Japan)); Yoshimura, Kazuki; Taga, Kazuo; Kohira, Takashi; Ishida, Tadaharu. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JEES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

The results of an accelerated aging test of Ni pigmented anodized aluminium coating and the clarified degradation mechanism are reported. Only the interesting result deduced from the result of infrared spectroscopy of the specimen degraded by the accelerated humidity test is reported. Two kinds of Ni pigmented aluminium were prepared which are named B and B^-. Heat loads of 280, 400 and 500°C with the aging times of 3, 50, 100 and 1000 hours, 3, 6, 10, 20, 50 and 100 hours, and 1, 3, 6, 10 and 20 hours were adopted for respective temperatures. Degradation was evaluated by the terms of solar absorptance before and after the test as the function of Ln t where t is the aging time. The Arrhenius equation seems to be effective for the service lifetime prediction of the specimen B^- within the temperature range employed for the test. The Eyring model can not be applied for specimen B^-. 1 ref., 3 figs.

7214 (JSES–8801, pp. 153-156) **Optical properties of ITO low-emissivity film.** Tazawa, Masato (Government Industrial Research Inst., Nagoya (Japan)); Yumakita, Norimi; Hayakawa, Jyo; Yoshimura, Kazuki; Tanemura, Sakae. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

The optical properties of commercially available indium tin oxide (ITO film) were investigated mainly by using the Drude's theory. The transmissivity and reflectivity were first measured. The reflection spectra were compared with the result obtained by the Drude's theory in the region from 400 nm to 700 nm where no fundamental absorption is observed. The transmission spectra and reflection spectra agreed comparatively well with the calculated results of the Drude's theory except in the wavelength region where fundamental absorption will be observed. Using an ellipsometer, parameters Δ and psi obtained by calculation were compared with the measured values. Disagreement was observed in some cases, and the cause for the disagreement seems to be the use of 3 phase-model (ambient (air), ITO film, substance (fused quartz)). The result of the study on the electron micrography indicated the existence of a mixed layer of ITO film and air on the substrate. The layer may affect the results of ellipsometric studies. 3 refs., 4 figs.

7215 (JSES–8801, pp. 157-160) **Preparation and characterization of V_2O_5 electrochromic thin films.** Yoshimura, Kazuki (Government Industrial Research Inst., Nagoya (Japan)); Fujii, Atsushi; Tazawa, Masato; Tanemura, Sakae. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

The dependence of electrochromic properties of V_2O_5 thin film on the film preparation conditions were studied. Samples prepared were: an unheated substrate with partial oxygen pressure of 0.2 P_a (Sample 1), unheated substrate with partial oxygen pressure of 0.4 P_a (Sample 2), unheated substrate with partial oxygen pressure of 5 P_a (Sample 3), substrate heated at 200°C with partial oxygen pressure of 0.2 P_a (Sample 4), and a substrate heated at 200°C with partial oxygen pressure of 5 P_a (Sample 5). Samples 1 to 3 and 5 were in amorphous state and sample 4 had been crystallized. The electrochromic properties were studied using diluted $LiClO_4$ solution as the electrolyte. The changes in color differed considerably depending on the conditions for growth. The measured result of composition ratio indicates the possibility of the formation of oxide with small oxidation number in the film of the sample grown with low partial oxygen pressure. The behavior of the change in optical density by electrochromism of the crystallized samples was different from that of the samples in amorphous state. 9 figs, 1 tab.

7216 (JSES–8801, pp. 193-196) **Snow-melting experiment by utilization of solar heat.** Kawagoe, Shigeichi (Hitachi Chemical Co. Ltd., Tokyo (Japan)); Kodama, Fumihiro. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA Joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Removal of the snow from roofs and roads in snowy regions is a big problem, nevertheless a snow melting system utilizing solar heat has been deemed impossible due to the dark image of snowy regions during the winter time and almost no such a system has ever been installed. However, the snow can be melt at the temperature which is only several degrees. Because of this, a system utilizing solar heat which is used for melting the snow in the winter and for supplying the hot water in other seasons was installed in Fukui City and snow melting experiments were conducted from December 1987 through March 1988. This article is a report of it outline. Concerning heat collectors, four flat copper plate selective absorption treatment collectors were installed at 45° inclination facing south. With regard to radiator panels, six sheets of copper tubes with copper fins were installed in three manners, namely burying in mortar, enclosing in a box structure covered with a glass plate, and exposed copper panel, and their radiation performance were compared. The surface temperature of radiation panels during snow accumulation was 0°C and they serve to melt the snow even in the day of poor insolation. Among the three kinds of arrangements above, the glass panel showed poorer performance. 2 refs., 5 figs., 2 tabs.

7217 (JSES–8801, pp. 197-200) **Heat-balance calculation of heat collector using gas as convection inhibitor and result of heat radiation experiment with testing model.** Asai, Syunji (Yazaki Sogyo Kabushiki Kaisha (Japan)); Oshiro, Toru; Yamashita, Tetsushi. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

The main heat loss of the flat plate solar collector consists of the radiation from its heat collecting panel and the convection of the air layer between the heat collecting panel and the glass. In order to reduce the former, a selective absorption face plate is used and for the latter, two pieces of glass are used or a cellular structures is inserted into the space between its transparent panel and the heat collecting panel in order to control the air convection. In this study, in order to reduce heat loss due to the convection, various kinds of gas were used in lieu of the cellular structure in the heat collector and heat balance was calculated. In addition, a small heat collector model was made and heat radiation experiments were conducted by sealing various kinds of gas selected through calculation. As a

result, it was demonstrated that when gas other than the air was sealed in the heat collector, the heat loss due to the convection changed. In addition, it was found that when krypton and argon, etc. were sealed in the heat collector, its heat collecting performance was improved and a highly efficient heat collector of convection inhibiting type was made, but when freon and helium, etc. were sealed in the heat collector, its performance declined due to the increase of the heat radiation. 3 refs., 5 figs., 4 tabs.

7218 **Chemical and optical properties of a black copper absorber for flat plate collectors.** Vuletin, J. (Split Univ. (Yugoslavia). Faculty of Electrical Engineering); Bosanac, M.; Lampert, C.M.; Kulisic, P.; Mastelic, J. *Solar Energy Materials (Netherlands)*, 19(3-5): 249-256 (Nov 1989). DOE Contract AC03-76SF00098.

This investigation is about the development of a copper oxide on a copper solar absorber. This absorber has good wavelength selectivity alpha=0.97 and epsilon=0.16. The absorber is produced by direct chemical conversion onto a copper plate using a sodium hydroxide and potassium persulphate bath. Chemical analysis of the selective absorber was obtained by scanning Auger spectroscopy coupled with a sputter ion beam to give depth analysis. The results of the Auger analysis showed that the coating was mainly Cu_2O with an oxidized surface close to CuO in composition. Several impurities were identified in the coating. For efficiency measurements the black copper surface was applied to a collector. The slope and intercept of the efficiency curve was determined. The obtained values are close to those for black chrome. (orig.).

1420 Heat Storage

Refer also to citation(s) 7793, 7797, 7798, 7799, 7800

7219 (JSES–8801, pp. 221-224) **Basic study concerning laboratory system solar pond. Effects of wind speed and effects such as covering and salt concentration distribution, etc. by transparent films on the water surface.** Fukuda, Kenji (Kyushu Univ., Fukuoka (Japan)); Tanaka, Yoshihisa; Hasegawa, Osamu. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

In order to enhance the efficiency of the heat storage of a solar pond, in this study, problematical points concerning the heat storage of the solar ponds with and without salt were clarified and in order to solve and improve them, experiments were conducted on the case of using the salt water with concentration distribution, the case of using vinyl coverings, and the case of cooling the surface of the water by blowing. A 46cm high inner can of 35cm in diameter was set in a 90cm high outer can of 58cm in diameter in a manner of keeping the upper surfaces of both cans in the same level, the gap between the cans were filled with polystyrene foam for insulation and the water was filled up to 45cm in depth in the inner can. From the above experiments, it was found that the effects of evaporation on the surface of the water and wind speed were big for making the heat storage temperature of the solar pond much higher and for improving the heat storage efficiency. The degrees of the above effects could also be confirmed. In order to improve them, it is a simple and effective method to compose simply a transparent insulation layer with transparent films. In addition, it was also confirmed that the heat storage effect due to the convection inhibition effect by setting a concentration gradient in the liquid was fairly effective. 5 refs., 8 figs.

7220 (JSES–8801, pp. 205-208) **Study on temperature-selective heat-storage tank (No. 1).Trial manufacture of temperature-selective heat-storage tank and visualization of heat-storing process.** Kamiya, Yoshiyuki (Kanto-Gakuin Univ., Yokohama (Japan)). Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Since the temperature stratified heat storage tank has high heat storage efficiency, its tank can be made small in volume. However, in case when the heat sources fluctuate their heat supply like solar heat and waste heat and when the length of piping from the heat source is long and the operation becomes on and off frequently, the mixing loss inside the tank can not be avoided. In order to prevent the above, balanced heat storage tanks and stages temperature heat storage tanks are proposed, but concerning either type of proposed tanks, there is a defect that the temperature stratum is easily destroyed or the response to a widely fluctuating pattern is difficult. in order to solve the above defect, a temperature selective heat storage system having a damper to be operated by density difference was designed. This article is a report of the result of the experimental manufacture of a heat storage tank of the above system and the visualization experiment of the heat storing process. As the result of this experiment, it was found that the original target, namely the selective storage of heat in the same temperature layer, could be reached without disturbing the temperature stratum by mixing even when the supply temperature changed. 3 refs., 5 figs.

7221 (JSES–8801, pp. 209-212) **Effect of iron colloid in the method of heat storage in the underground aquifer.** Umemiya, Hiromichi (Yamagata Univ. (Japan)); Muto, Takeshi. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

As a result of field experiments of the method of heat storage in the underground aquifer, it is considered that improvement of heat recovery rate (recovered heating value/injected heating value) is due to the contribution of the formation of a heat storage domain under no influence of the natural underground stream within the heat storage aquifer and such formation is made by ferric hydroxide colloid which is generated through oxidation of iron included in fine quantity in the underground water. Hence, the effect of colloid on the heat storing performance of the aquifer was investigated by measuring the total amount of residual iron in the aquifer, permeability coefficient and apparent thermal diffusivity. This article is a report on the above. As a result, it was revealed that colloid affected considerably permeability coefficient and apparent thermal diffusivity. In other words, colloid inhibits the natural underground stream by creating dam-shaped cloggings in the gaps of the aquifer, thereby permeability coefficient and apparent thermal diffusivity go down. When injection of the water including ferrous iron from the well and backwash which follows afterward are conducted for a long period, the above clogged domain is expanded creating the heat storage domain and the heat recovery rate is drastically improved. 2 refs., 8 figs., 1 tab.

7222 (JSES–8801, pp. 213-216) **Cogeneration system using underground aquifer heat-storage system at the same time.** Umemiya, Hiromichi (Yamagata Univ. (Japan)); Sato, Yoshihiro. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA Joint Conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

This article is a report on the study result concerning profitability of the Cogene ATES (Cogeneration based on aquifer thermal energy storage) system which connected the co-generation system with advantages of energy saving and reduction of energy cost and the underground aquifer heat storage system using two wells for injecting into the underground aquifer for storage the warm water made by natural energy mainly through insolation in the summer and extracting it for use in the winter. As revealed from the study, the above system utilizes a great quantity of energy throughout a year by storing heat in using an underground aquifer, hence energy cost can be reduced to about 1/4. in addition, as also revealed, the overall outcome coefficient throughout a year becomes 1.46 demonstrating its excellence as a system. Furthermore, as the result of evaluating profitability of the above system in terms of the number of years required for recovering its initial cost, it was found that the initial cost could be recovered in 12.3 years in case when the heat recovery rate was 60%, the rate of increase of fuel cost was 1%/

year and the rate of increase of electric power rate was 3%/year. 1 ref., 9 figs., 4 tabs.

7223 (JSES–8801, pp. 217-220) **Study concerning effective utilization of underground heat storage system by physical property of the Soil (No. 3). Basic radiation characteristics of heat storing and radiating body and result of long term experiment.** Nakajima, Yasutaka (Kogakuin Univ., Tokyo (Japan)); Ohashi, Kazumasa; Mochizuki, Shintaro; Uchiyama, Tadashi; Takemura, Akihiro. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

This article is a report concerning elapsed time changes throughout a year of the respective physical property of the soil inside the underground heat storage thank and the soil outdoors, the basic radiation characteristics depending upon the differences of shapes of heat storing and radiating bodies and the long term heat storage and recovery experiment. A summary of the results is as follows: (1) It was confirmed that the elapsed time changes of each physical property value of the soil outdoors and the soil within a panel-pipe tank had its own characteristic. (2) It was confirmed that the panel radiated more heat in the beginning of radiation and showed a trend of decrease as time passed, but the pipe radiated a constant amount of heat gradually, because of the basic radiation characteristics depending upon the shape difference between the heat storing and radiating bodies. (3) From the basic heat radiation characteristics of the heat storing and radiating bodies and the result of the long term experiment, it became clear that the panel tank could store and recover heat in a short time and the pipe tank could do in a long time. (4) It was confirmed that during the long term experiment this time, air-conditioning for about 50 days could be done by the amount of heat recovered through the underground heat storage system which was used in the experiment. 4 refs., 15 figs., 3 tabs.

7224 (NEI-SE–39, pp. 77-81) **Heat storage in clay at Soederkoeping: Geotechnical follow-up and evaluation. .** Rydell, B.; Sundberg, J. Statens Geotekniska Inst., Linkoeping (Sweden). 1988. (In Swedish). (CONF-8805342–: Nordiska Geoteknikermoetet, Oslo (Norway), 13-15 May 1988). In *Nordiska Geoteknikermoetet.* Order Number DE90705986. Available from NTIS (US Sales Only), PC A05/MF A01; NTIS (US Sales Only), PC A04.

SGI - Swedish Geotechnical Institute - has for several years studied systems for heat storage in the ground. Heat storage results in an increase of the original ground temperature. The article describes a follow-up and evaluation of a lesser heat store with vertical pipe system in clay. Changes in pore pressure preconsolidation pressure are discussed. The sand drainage installed together with each heat exchanging U-tubes has not had any apparent positive effect on the clay properties. The advantage is limited to an improvement in the U-tube heat transfer properties. As the preconsolidation pressure is temperature dependent great caution should be used when locating heat stores in clays of normal or low consolidation, particularly by high temperature storage. Other factors to pay attention to are ground surface utilization and foundation of adjoining buildings. Location of heat stores in sloping clay ground should be avoided. As a general conclusion may be stated the need of a careful preliminary geotechnical investigation as a foundation of recommendations for building and operation of heat stores in clay. (O.S.).

15 GEOTHERMAL ENERGY

1501 Resources and Availability

Refer also to citation(s) 7262

7225 (GRSJ–8901, pp. 1-6) **Exploration of the Rotokawa geothermal field, Taupo volcanic zone, New Zealand.** Browne, P.R.L. (Univ. of Auckland (New Zealand)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The Rotokawa geothermal field is located 7 km east of Wairakei, New Zealand, and has been investigated for its sulphur resources and power potential over the past 50 years. Exploration of the field has slow and mostly unsystematic. The depths of the drill holes are less than 50 m until 1964. Since 1965 the exploration has been carried out systematically. Three, one and four exploration wells were drilled in 1965-66, 1977, and 1984-86 respectively. Finding Jurassic greywackes and argillites at a depth of 2200 m below a thick (ca. 900 m)sequence of two pyroxene andesite lava flows had an important significance, because the Jurassic rocks are the basement rocks for the North Island. The Rotokawa geothermal field represents an important resource with an assessed potential of 49 MW (proven), 100 MW (probable) and 200 MW (possible), though these figures are considered to be probably optimistic. Further exploratory drilling is needed. The main development problems at this stage are: (1) encountering good subsurface permeability, (2) identifying and combating corrosive CO_2-rich fluids, (3) determining the most favorable reinjection conditions; this is a problem, ironically enhanced by the hot temperature and the consequently high silica contents of the thermal fluids, (4) establishing an acceptable development plan for the field which accommodates the requirements of both the sulphur mining interests, the power producers, and especially the Ngati Tahu maori owners of the land. 24 refs., 2 figs., 2 tabs.

7226 (GRSJ–8901, pp. 287) **New Mexico geothermal exploration and development. Decade of experience.** Whittier, J. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

New Mexico possesses a low-temperature geothermal resource base. Most of the resource base lies within the Rio Grande Rift and is largely co-located with the population centers of the state. Since 1978, coordinated linking of state government, universities, and private firms has resulted in a multi-faceted approach for development of the geothermal resource base for economic development initiatives. Positive results of the combined efforts are beginning to appear. Ten years ago there were no companies using geothermal energy in New Mexico. Geothermal-related firms now employ over 100 persons and their employees make annual income tax payments in excess of 200,000 dollars. New policy directions are emerging in response to the needs of current and future geothermal users. Financial incentives are being phased out and replaced with technical assistance services. Engineering and regulatory assistance programs have supplanted exploration services, largely because the resource base is now relatively well defined. A variety of promotional efforts are directed toward attracting businesses to utilize the resource base.

7227 (GRSJ–8901, pp. 268-271) **Geothermal energy resources and geothermal drilling in China.** Geng, Weihong (Inst. of Geology Information, Beijing (China)); He, Yizhang. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In China, the geological structure is complex and rich, and the geothermal energy resources cover all the country, since affected by geothermal girdle of Mediterranean Sea-Himalayas and several geotectonic fault zones, as well as uplift and depression of many structural basins. So far, the hot springs and geothermal wells drilled in China have been more than 3,000. Some smaller scale power stations have been built in high temperature field. Meanwhile the extremely rich middle/low temperature geothermals have also been widely used in respect of the industry, agriculture, medical treatment, etc. The key points of future geothermal drilling in China are the increase in complement of drilling equipment for the exploration and development of high temperature and deep geothermals, research in new direction drilling system using downhole drilling motors and others for the increasing yield of well, development of high

temperature resistant mud and corrosion proof flushing fluid/air foam systems, and R and D of high temperature resistant roll bits and polycrystalline diamond bits. 5 refs., 2 figs., 2 tabs.

7228 (GRSJ–8901, pp. 272) **On geothermal resources of India. Geotectonic aspects and recent developments.** Gupta, M.L. (National Geophysical Research Inst., Hyderabad (India)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Research programs launched for exploration and development of the geothermal energy in India, since the 1973-1974 oil embargo, have led to the identification of many potential areas for geothermal resources. Resources comprise high/intermediate/low temperature hydrothermal convection and hot water aquifer systems, geopressured geothermal system and conduction-dominated regimes. Location and properties of these geothermal systems are controlled by the geodynamic and tectonic characteristics of the Indian continental lithosphere Main sectors for the utilization of India's proved and identified geothermal resources are the power generation, space heating, green house cultivation, aquaculture, poultry, sheep breeding, mineral processing, mushroom raising, processing of farm and forest produce, refrigeration, tourism, health-resorts and mineral water bottling. The R and D efforts have given some encouraging results. Geothermal resources of India, although primarily are of medium to low grade, could supplement, to a great extent, direct heat energy needs and may also provide electricity to some of the remote hilly areas. Development of geothermal energy sources in India is likely to get some more attention, with the setting up of separate departments and agencies, by various Provincial Governments, for R and D backing toward the alternate sources of energy.

7229 (GRSJ–8901, pp. 287) **Deep geothermal reservoirs in the Pannonian basin. New results and perspectives.** Stegena, L. (Eoetvoes Univ., Budapest (Hungary)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The low-enthalpy geothermal reservoirs of the Pannonian basin, Hungary are of generally connate waters of the young-Tertiary sediments of the basin. Theoretical considerations have recently showed that the existence of high enthalpy reservoirs in greater depths of the basin is possible. These considerations are based on the elevated heat flow density, meaning the high geothermal gradients to be continued in bigger depths, too, at least partly and several boreholes reaching the Mesozoic or Paleozoic basement of the basin, showing considerable secondary porosity to exist in the basement. In order to approach the geographic setting of the supposed deep-seated geothermal reservoirs, the areas with Mesozoic carbonate rock basement were delineated, by using borehole data. By comparing these areas of Mesozoic carbonate with the geothermal maps, the areas, where the top of Mesozoic carbonate is warmer than 150°C, were marked out. Based on hydrogeological and borehole observations, there are some conceptions referring to the distribution of the karstified and fragmented zones of the carbonatic basement. Though existing in fluid state, water is salty and not applicable for turbines. It is hoped however that in other places of the Pannonian basin, deep-lying reservoirs are filled with infiltration or reinfilitration water, the salinity of which is much more lower. 1 fig.

7230 (GRSJ–8901, pp. 290-292) **Thermal regime and geothermal energy recovery potential of the western Canadian sedimentary basin.** Jones, F.W. (Univ. of Alberta, Edmonton (Canada)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Temperature regime of the Western Canadian Sedimentary Basin was investigated using bottom-hole temperature from petroleum exploration wells. Comparison of the vertical temperature gradients and heat flows across two intervals of the sedimentary section indicated the reduced heat flow through the upper interval in the south and west, and increased heat flow in the north and east. It suggested that the strong effect of heat transport by groundwater motion from mountains in the south and west towards northeastern lowlands. Since temperature at the basement surface of the sediments in Alberta was indicated to be not a function of depth only, it was suggested that regional and local hydrodynamics should be considered for the exploration of shallow geothermal energy recovery sources. The conditions for possible geothermal energy recovery for these areas in Alberta were investigated by use of temperature, flow rate and water quality data, and the temperature at 3km depth for the areas was consequently favorable for geothermal energy recovery. The existence of formations suitable for energy recovery were revealed from the flow rate and information on amounts of dissolved solids in the areas. 4 figs.

7231 (GRSJ–8901, pp. 330-333) **Hot springs, geothermal fields, and plate tectonics in Japan.** Acharya, Hemendra (Stone and Webster Engineering Corporation, Boston, MA (USA)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Hot springs are, in general, situated in the volcanic belt of a convergent zone and are utilized as indicators of geothermal potential in an area. The locations of hot springs (with temperatures>90°C) in Japan, have been examined to determine the influence, plate underthrusting exerts, in determining the locations of these hot springs. This examination shows that hot springs and geothermal fields in Japan are situated in the volcanic areas along the extension of zones which mark discontinuities in plate underthrusting. Measured heat flow in many of these zones is higher than average for volcanic areas. Such zones with higher than average crustal temperatures should be prime targets for comprehensive geothermal exploration programs. Springs in volcanic areas confirm three required characteristics, for geothermal fields, namely, heat source, rock permeability and ground water availability. If temperature at shallow depth (<2Km) is high> (180°C) in such areas, then geothermal energy can be exploited. 11 refs., 2 figs.

7232 (GRSJ–8901, pp. 343-346) **Mineral and thermal waters in Czechoslovakia.** Vylita, B. (Stabeni geologie Praha, Prazska (Czechoslovakia)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Czechoslovakia consists of two principal European geological units. In the west, Bohemian Massif is a part of the late Paleozoic Variscan orogenic belt. In the east, the West-Carpathians are the part of the Alpine Mountain System. Both units differ not only in their geological age and paleogeography, but also in structural development, geomorphology, magmatic and volcanic history. Bohemian Massif has been consolidated during the Variscan orogeny in Late Paleozoic. Consequently, the platform sediments or younger age have been affected only by faulting. A considerable part of this massif is built up by crystalline schists and granitoids. The most intensive young tectonic activity (Saxonic) here took place in Tertiary. In the east, Bohemian Massif adjoins West-Carpathians which form an arc of the Alpine Mountains of Mesozoic and Tertiary ages. Their crystalline basement has been built by earlier orogeny. Neogene basins and areas of Tertiary volcanism terminate the geological development of this unit. Mineral waters are related to all five zones of West-Carpatians, showing different conditions for their origin. Different are also genetic types of waters and their varied chemistry. More than 2,000 mineral and thermal water occurrences have been registered. Nowadays, there are 60 spas in the country, visited yearly by 460,000 patients. About 360 million bottles of mineral water are produced in 22 bottling plants yearly. Only a small amount of geothermal energy is used in agriculture, pools and for heating. There are no favorable conditions for geothermal power stations in Czechoslovakia. 3 figs., 4 tabs.

7233 (GRSJ–8901, pp. 404) **Exploration and development of geothermal water resources for agricultural use Hokuriku district.** Yamamoto, A. (Agricultural Administration Office, MAFF, Ishikawa (Japan)); Ito, Y,. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The relation between geothermal gradients and the geology is investigated in Hokuriku district, Central Japan. Geothermal gradients are mainly inferred from reviewing borehole logs for hot springs. These are classified into the following five groups according to geological distribution. (1) Large geothermal gradients (0.06-0.10°C/m) with some hot springs around the recent volcanoes. (2) Mostly large geothermal gradients (0.04-0.10°C/m) with some hot springs on the granitic rocks. (3) Moderate to large geothermal gradients (0.04-0.10°C) with many hot springs on the Neogene volcanics. It is though that these areas have been lifting up in the Recent. (4) Moderate to small geothermal gradients (less than 0.04°C/m) on the alluviums and thick sedimentary rocks in the Neogene. It is thought that these areas have been sinking in the Recent. Occasionally hot springs are obtained by drilling more than 1,000m deep. (5) Mostly small geothermal gradients (less than 0.03°C/m) with rare hot springs on the strata in the Paleogene.

7234 (INIS-mf–12034) **Report on continuation of work on the project 'methods of measuring heat generation KTB programme'.** Gohn, E.; Becker, K.H. Goettingen Univ. (Germany, F.R.). Geochemisches Inst.; Deutsche Forschungsgemeinschaft, Bonn (Germany, F.R.). 1989. 10p. (In German). Contract DFG Go 457/1-2. Order Number DE90732393. Available from NTIS (US Sales Only), PC A02/MF A01.

In the framework of the Continental Deep Drilling Program the U, Th and K concentration analyses required for the determination of the heat production rate of rock are carried out by borehole measurements and by analyses of drill cores, bore dust and cuttings in the field laboratory. These measurements provide the data necessary for continuous monitoring of heat production. They are, however, influenced by disturbing factors leading to systematic deviations. A comparison with lab analyses of cores shows that the heat production rates calculated from the results of borehole measurements are too low. The differences depend on the lithology of the rock. The average lies at about 20%. These differences are caused by disparities in the U concentration analyses and initiated by a disturbance in the radioactive balance of the U-238 radioactive chain (Rn loss at borehole walls). Analyses of bore dust show that this material is not able to correctly reproduce variations of the heat production. The heat production is averaged for large areas and underestimated (depletion of the elements traced in the centrifuge material by enrichment in the drilling fluid). (orig./HP).

7235 (LA-UR–86-2600, pp. 86-89) **Geology of Honduran geothermal sites.** Eppler, D.B. Los Alamos National Lab., NM (USA). Fal 1986. In *Los Alamos science, Number 14.* Order Number DE87003612. Available from NTIS, PC A06/MF A01.

A team of Laboratory geologists has been working with counterparts from the Empresa Nacional de Energia Electrica (ENEE) of Honduras and from four American institutions on a project to locate, evaluate, and develop geothermal resources in Honduras. The team, headed by Grant Heiken and funded by the US Agency for International Development, has so far completed tree trips to Central America to study in detail the geology of six geothermal springs sites. The project has two goals: selection of two geothermal sites for further development on the basis of detailed studies, by Los Alamos and ENEE geologists, of the six previously identified sites; and identification of other promising geothermal sites on the basis of a country-wide inventory of hot springs by ENEE with technical support, as necessary, from Los Alamos.

7236 (LA-UR–86-2600, pp. 90-93) **Geochemistry at Honduran geothermal sites.** Goff, F.; Grigsby, C.O.; Shevenell, L.A.; Gutierrez, J.W. Los Alamos National Lab., NM (USA). Fal 1986. In *Los Alamos science, Number 14.* Order Number DE87003612. Available from NTIS, PC A06/MF A01.

In May 1985 a team from Los Alamos National Laboratory, the United States Geological Survey, and the Empresa Nacional de Energia Electrica (ENEE) carried out hydrogeochemical studies at six major hot-spring systems in the western half of Honduran. The locations of these systems are noted on the map in Geology of Honduran Geothermal Sites. The team analyzed water samples of concentrations of major and trace elements, stable isotopes, and tritium, gas samples for concentrations of carbon dioxide, hydrogen sulfide, methane, and other gases, and rock samples for concentration of carbon and oxygen isotopes. The results of the analyses were used to assess the suitability of the sites for geothermal development. By combining the information obtained from geochemical and geologic studies, the temperature and flow dynamics of a site can be evaluated before the more expensive step of drilling begins.

7237 (LBL–27598) **Some considerations on resource evaluation of The Geysers.** Bodvarsson, G.S.; Gaulke, S.; Ripperda, M. Lawrence Berkeley Lab., CA (USA). Aug 1989. 11p. Sponsored by California State Lands Commission; U.S. DOE Conservation & Renewable Energy. DOE Contract AC03-76SF00098. (CONF-891031–9: Annual meeting of the Geothermal Resources Council, Santa Rosa, CA (USA), 1-4 Oct 1989). Order Number DE90002119. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Although large amounts of data have been collected at The Geysers, some reservoir parameters, such as initial liquid saturation, matrix permeability and the fracture network characteristics, are still poorly known. These parameters greatly affect results of resource evaluation and predictions of reservoir behavior. Several two-dimensional fractured porous medium models have been developed for The Geysers; these models differ in assumptions regarding the initial liquid saturation and matrix permeabilities. These models indicate that the permeability-thickness product (kH) of the fracture network ranges from 10 to 75 Dm (30,000 to 225,000 md·ft) and matrix permeability ranges from 1 to 3 μDarcies (μD). All three models yielded surprisingly similar predictions regarding the future generating capacities of different areas. 17 refs., 6 figs.

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Refer also to citation(s) 7224, 7230, 7234

7238 (GRSJ–8901, pp. 28-30) **Fracture systematics in high-temperature geothermal fields. Roles of inherited structures and stress field reorientation.** Nielson, D.L. (Univ. of Utah Research Inst., Salt Lake City (USA)); Hulen, J.B.; Allison, M.L. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The present authors discuss that the inherited structures and stress field reorientation in hydrothermal field are playing important role as hosts for fluids. As an example on the fault systems for the passage of hydrothermal fluids, Roosevelt Hot Springs (RHS) is introduced. RHS is an example of a high-temperature geothermal system associated with a rhyolite dome complex. In this region, the two families of orthogonal normal faults (Opal Mound and Negro Mag) exist and especially Negro Mag fault are important for thermal fluid systems. In contrast, the Jemez faults at the Valles caldera predominantly inherited by surrounding geological structure are playing important role in producing geothermal systems, whereas the channeled faults formed by volcanic processes also are the case. Based on the above examples, the present authors emphasize that the understanding the genesis of different families of faults and the orientation of faults with respect to current stress field is a clue to the finding of the hydrothermal reservoir. 9 refs., 1 fig.

7239 (GRSJ–8901, pp. 65-68) **Double-diffusive convective transfer of thermal energy within the Salton Sea geothermal brine.** Fournier, R.O. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.*

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This paper emphasized that the double-diffusive convection model is suitable to explain the variations on pressure, temperature, heat flow, and salinity observed thorough the Salton Sea geothermal system. The author denied several other models for the Salton Sea hydrothermal system which consist of the model of large-scale convection, the model of the diffusion of water downward, the model of the distribution of brine in response to a temperature gradient and the model of small vertical convection accompanied with large-scale horizontal flow. The author concluded that the important parameters are the contrasting rates of transport of heat and salt across a boundary layer separating cooler less saline water above from hotter more saline water below and that this model can explain the density profile of the hydrothermal reservoir consistently. 17 refs., 1 fig., 1 tab.

7240 (GRSJ–8901, pp. 15-18) **Promising geothermal resources in the Neogene volcanitectonic depressions along the volcanic front of northern Honshu, Japan.** Utada, M. (Univ. of Tokyo (Japan)); Ito, T. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In this paper, heat source, history of hydrothermal activity and water circulation system in northern Thailand are discussed on the basis of heat generation data, thermoluminescence dating, fluid inclusion and alteration mineral studies and existing chemical data. Analyses of radiogenic elements (U, Th K_2O) were carried out by gamma-ray spectrometry of 1024 channel analyzer and calculating the value of heat generation. As a result, two high heat generation unit areas, Mae Chaem-Mae Sariang and Chiang Rai-Mae Chan, were identified. There no good relation with the above HGU and hot spring distribution. The thermoluminescence dating of altered rocks of drilling cores, quartz veins and altered rocks range from 0.047 to 0.90 Ma and indicate young ages are identified at the presently active hot spring sites and old ages are found in the areas far away from hot spring site or alteration halos with no thermal manifestations. The authors made a schematic model for hydrothermal system. 7 refs., 3 figs., 1 tab.

7241 (GRSJ–8901, pp. 19-21) **Heat source and hydrothermal systems of non-volcanic geothermal resources in northern Thailand.** Takashima, I. (Akita Univ. (Japan)); Honda, S.; Kita, I.; Raksaskulwong, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In this paper, heat source, history of hydrothermal activity and water circulation system in northern Thailand are discussed on the basis of heat generation data, thermoluminescence dating, fluid inclusion and alteration mineral studies and existing chemical data. Analyses of radiogenic elements (U, Th K_2O) were carried out by gamma-ray spectrometry on 1024 channel analyzer and calculating the value of heat generation. As a result, two high heat generation unit areas, Mae Chaem-Mae Sariang and Chiang Rai-Mae Chan, were identified. There no good relation with the above HGU and hot spring distribution. The thermoluminescence dating of altered rocks of drilling cores, quartz veins and altered rocks range from 0.047 to 0.90 Ma and indicate young ages are identified at the presently active hot spring sites and old ages are found in the areas far away from hot spring site or alteration halos with no thermal manifestations. The authors made a schematic model for hydrothermal system. 7 refs., 3 figs., 1 tab.

7242 (GRSJ–8901, pp. 22-25) **Origin of Northern Thailand geothermal systems as indicated by isotopichydrogeology.** Ratanasthien, B. (Chiang Mai Univ. (Thailand)); Ramingwong, T.; Tunsakul, L. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Isotopic hydrogeochemical study were performed on San Kamphaeng, Pa Pae and Mae Chan geothermal systems from Thailand. The isotopic results of oxygen-18 and deuterium show isotopic ratio lie close to the meteoric line. The results of those thermal water are trending toward negative value. Their systems are similar in character of hot-water dominated type, high pH, with sodium carbonate species and associated with granitic rocks. The deuterium and oxygen-18 values suggest the origin of water may have been derived from local precipitation, possibly from somewhat higher altitudes. Tritium isotopic analysis indicate the thermal water from Fang, Pa Pae and Mae Chan show slightly higher value than those of San Kamphaeng. The lower tritium unit of San Kamphaeng system than the others could be attributed either to the longer period of ground water (meteoric water) circulation before being heated up and discharged as hot springs and/or a different ratio between deep and shallow groundwater. 3 refs., 1 fig., 1 tab.

7243 (GRSJ–8901, pp. 26-27) **Numerical analysis of geological structure and fracture system in the Kurikoma geothermal area.** Mizugaki, K. (Geological Survey of Japan, Tsukuba); Kodama, K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This report describes a two-dimensional finite numerical analysis of deep-stratum geologic structures and the actual fracture systems in the Kurikoma geothermal area, Akita prefecture, Japan. The experiments were conducted on the development processes of geologic structure by dividing them into five steps. In sequence, they are the deformations during sedimentation of Doroyu formation, Torageyama formation, with uplifting of the central area, during sedimentation of Sanzugawa formation and with uplifting of the central area. The configuration of deformation and fracture based on the simulation is expressed schematically. It is evident that the highly fractured vertical zones exist between subsided and uplifted zone, such as Uenotani and Akinomiya. It can be seen also that the radial distributed fracture systems are around the uplifted zone. The distribution of the fracture system shown by this numerical experiment is consistent to represent the fault structures actually surveyed from field research. 3 refs., 1 fig.

7244 (GRSJ–8901, pp. 31-34) **Fingerprint geochemical survey applied to Onikobe Okunoin geothermal area.** Suzuki, T. (Electric Power Development Co., Ltd., Tokyo (Japan)); Abe, M.; Higashihara, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This report describes the analytical results of mass spectrometry for soil gas absorbed by activated charcoal in the large hydrothermally altered zone named Okunoin from Onikobe geothermal area in northeastern Japan. By cluster analysis, 134 mass spectral patterns obtained by mass spectrometry were classified into 16 clusters and they were grouped into four groups(1, 2, 3, 4)based on mass peaks patterns. The widest zone of high gas emission(1) corresponded to the prominent fracture. On the other hand, the widest zone of low gas emission(3) was restricted in the presumed fault. It was also found that the fault zone was characterized by the gas pattern as high-low-high. The present authors interpreted above data by assuming operating model which is schematically shown with the development of the geothermal alteration. The high gas emission is interpreted with spout of geothermal fluid along fault/fracture. Because of the closure of the fracture by the sealing with clay minerals, the low gas emission zone was formed. 4 refs., 6 figs.

7245 (GRSJ–8901, pp. 44-46) **Hydrothermal alteration and geothermal structure in the Takigami geothermal area, Kyushu, Japan.** Yamamoto, Y. (Idemitsu Kosan Co., Ltd., Tokyo (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov

1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This paper describes the classification of hydrothermal alteration in the Takigami geothermal area, Kyushu, Japan and geothermal structure under consideration based on the temperature profiles observed in the wells. The author divided hydrothermal alteration zones into two types based on Utada(1980), acidic alteration zone and intermediate one. The characteristic mineral of the former zone consist of kaolinite, dickite, alunite, pyrophyllite and large amount of anhydrite. In contrast, the characteristic minerals of latter zone consist of montmorillonite, sericite/montmorillonite, sericite and chlorite. The Takigami geothermal area can be divided into three zones stratigraphically. The first layer consists of unaltered porous Quaternary volcanic rocks, whereas the lower limit of the first layer consists of montmorillonite zone which prevent the movement of the cold meteoric water within the first layer. Acidic alteration zones in the geothermal reservoir show low permeability. The high permeable zones are expected outside the acidic alteration zone. 1 ref., 4 figs.

7246 (GRSJ–8901, pp. 59-62) **Geochemical models for reservoir processes at Cerro Prieto, Mexico.** Truesdell, A.H. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The present author reviewed the geochemical data on the geothermal reservoir from Cerro Prieto in Mexico where the world's largest hot-water is producing and made an operating model for explanation of reservoir process. The present author summarized the geochemical characteristics of reservoir under consideration from chemistry of surface and deep fluids, chemical thermometry, changes due to production and fieldwide changes, reservoir process near individual well. Especially, in the well M31, it was observed that the enthalpy (TE) decreased exponentially with time elapse from 1971 to 1983 whereas the Na-K-Ca temperature (TNKC) and the quartz saturation one (TSIL) decreased gradually. The tendency of TE > TNKC > TSIL in the same well is explained that the fluid in the reservoir suffered from near-well boiling with fluid cooling. 19 refs., 5 figs.

7247 (GRSJ–8901, pp. 97-101) **Assessment of total heat and mass transfer of a large hot pool using the balance method. Ohaaki pool, broadlands-Ohaaki geothermal field, NZ.** Hochstein, M.P. (Univ. of Auckland (New Zealand)); Henrys, S. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Hot pools with minor discharge of chloride water can often be found over large hot water systems. These pools are fed by deep thermal fluids which usually have been mixed with less mineralized shallow water and which ascend along deep reaching fracture zones. These pools occupy and older hydrothermal eruption crater. The water in the pool is clear and deposition of silica occurs at the margin often forming overhanging deposits. Evaporative heat losses are high because of the high surface temperature but natural overflow is usually small. The concentration of chemical constituents of the hot water is almost constant over long periods indicating that the total upflow is significantly greater than the total mass flow given by evaporation and natural overflow. The study has shown that the total heat and mass transfer is significantly greater than that given by surface losses and that a large concealed outflow of hot water is required to explain the unchanged chemistry of the pool in its natural state. The total heat transferred is about 2 times greater than that assessed from surfaces losses. The same findings should also apply to other clear hot pools including those with no natural overflow but for which constant concentration of chemical constituents is documented. Constant chemistry of hot pools implies that there is always a large concealed outflow of hot water associated with these features. 6 refs., 2 figs., 1 tab.

7248 (GRSJ–8901, pp. 128-132) **Geochemical model of the Matsukawa geothermal field.** Yoshida, Y. (Japan Metals and Chemicals Co., Ltd., Iwate); Ishizaki, H. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This paper presents a model of the Matsukawa geothermal system, based on the distribution of chemical composition of geothermal steam. Production wells in the area can be divided into the following two groups: the one of the eastern part of exploitation zone, of which steam is rich in CO_2 and poor in H_2S; the other one of the central and western part, of which steam shows opposite characteristics to the former. The difference between the above two groups concerning carbon isotopic composition of CO_2 and tritium concentration suggests that the contribution of surface water to steam of the former group is greater than to that of the latter. On the other hand, He/Ar and N_2/Ar ratios of steam show that the former group is more strongly contributed by volcanic gas. Combining these chemical data with the geological structure of the area, the authors conclude the existence of two kinds of geothermal fluid, one from southeast area and the other from southwest. 8 refs., 5 figs.

7249 (GRSJ–8901, pp. 180-183) **Transient heat transfer from a circular cylinder with constant surface heat flux in a saturated porous layer. Application to underground water velocimetry.** Kimura, S. (Government Industrial Research Inst., Tohoku, Sendai (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

By simulating a heat generating probe positioned perpendicular in an aquifer, the transient heat transfer, from the cylindrical object in the vapor-saturated porous layer, was discussed. The heat flow was assumed to be constant in velocity on the cylinder surface, while the underground water flow was done rectangular to the cylinder axis. Immediately after the heat generation, the heat boundary layer being thin without convection, the transient heat transfer is dominant. However with the elapse of time, the heat boundary layer growing, the heat removal due to the convection of underground water equilibrates with the heat source. If the underground water flow is high in velocity,the heat boundary layer is thin at the steady state, which is achieved in a short time. If the cylinder surface is normalized in temperature, a universal temperature pattern, which is independent of the flow velocity, can be obtained. However against the restriction in presumed condition, etc., a numerical solution method, effective in all the processes of transient heat transfer, was derived, by which the effective heat transfer ratio of aquifer and underground water flow velocity can be determined, if the timely heightening in surface temperature and time to achieve the steady state are measured. 4 refs., 6 tabs.

7250 (GRSJ–8901, pp. 102-103) **Thermal process and geothermal energy in and around the Yakedake volcano, Gifu-Nagano, Japan.** Iriyama, J. (Chubu Univ., Aichi (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This is the observation on the surface manifestation of geothermal energy in and around the Yakedake volcano. In the year 1987, there were six solfatara in the northern summit dome of Yakedake, of which the measured temperature were from 61 to 93°C. The measured temperatures of eleven fumaroles in the southern summit dome of Iwodake were from 40-65°C. There are many hot springs, a geyser and a travertine terrace along the Gamada River on the northwestern foot of the volcano, showing the direction of geothermal energy discharge from the magma body. 4 figs.

7251 (GRSJ–8901, pp. 105-108) **Microearthquake study of the fracture structure in the Takinoue geothermal area.** Sugihara, Mitsuhiko (Geological Survey of Japan, Tsukuba); Tosha,

Toshiyuki. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Promising methods, potentially able to resolve the underground fracture structure, for analyzing the microearthquake data, with an accuracy by an order of 10m, were described in this paper. Microearthquake activities in the Takinoue geothermal area, Iwate Prefecture, Japan, where high temperature fluid rises through fractures, penetrating a hot body of intrusive rock, have been observed since December, 1982. Hypocenter locations of numerous microearthquakes, recorded by eight permanent stations during a pressure build-up test in June, 1985 and presumably associated with fractures within the intrusive rock, were determined. Precise analysis of microearthquake signals provided a clear hypocenter distribution, characterized by an NNW-SSE trending vertical plane consisting of a series of small faults and, as a result, accurate delineation of previously unavailable fracture structure. A strong signal in 0.1sec after the P-wave arrival, i.e.., later feature was observed and judged to be due to the exposure of rock and weakness of direct wave, because of the source radiation pattern. The hypocenter locations were determined, by assuming a layered velocity structure and using the HYP071 program. The proper analysis of source process and clarity of first motion record were also explained. 6 refs., 9 figs.

7252 (GRSJ–8901, pp. 109-112) **Fracture system and fluid flow in the Takinoue geothermal area inferred from the microearthquake study.** Ito, H. (Geological-Survey of Japan, Tsukuba); Sugihara, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Geothermal exploitation, and geophysical and geological investigation at the geothermal area lead to recognize the importance of fracture system in the geothermal reservoir. Fluid flow in rock plays a central role in the geothermal energy recovery. Fracture acts as a major fluid flow path. Permeability is controlled by fracture and not homogeneous as in the case of porous media. Therefore, the mapping and evaluation of characteristics is of a crucial importance. However, few results give a sufficient knowledge on the fracture system, e.g.., three-dimensional configuration of the fluid flow path and permeability. In this paper, the fracture system and fluid flow, in the Takinoue geothermal area, based on the microearthquake data, were discussed. The hypocenters of microearthquakes are closely related with the fracture density and pore pressure, and may represent a geothermal reservoir. In some cases, the fluid flow paths can be estimated by the hypocenter distribution and permeability from the migration rate. The three-dimensional velocity structure and focal mechanism can be obtained, for each microearthquake event, by the observation at numerous seismic stations. 9 refs., 7 figs.

7253 (GRSJ–8901, pp. 113-116) **Development of a full-automatic monitoring system of microearthquakes for geothermal development.** Ikawa, T. (Japex Geoscience Inst., Inc., Tokyo (Japan)); Kuroda, T.; Hashida, I.; Nakagome, O. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A06/MF A01.

The observation of microearthquakes is required for the environmental monitoring in the geothermal development, while useful for the detection of the subsurface structure in terms of seismic velocity and fracture distribution. For such a purpose, an accurate recording of earthquake waveform is necessary in a range of magnitude between -2 through 4. It is found that at least 102db of dynamic range of recording is required for the earthquake in the above magnitude. Therefore, a rapid auto-gain-ranging digital amplifier, which is an Instantaneous Floating Point (IFP) amplifier, was adopted in the new system. The IFP amplifier works, to fill A/D converter bits over 90% changing its gain which can vary from 0 to 84db with a 6db-step at each digitizing instance. Consequently, the IFP amplifier system achieves a dynamic range recording of 120db or more without human intervention. The data from three seismometers are digitized at every 5msec and transmitted through telephone line to the central computer on a real time basis. The computer scans the input data from all the stations so that all the earthquake events are detected, analyzed and filed automatically without missing. In addition, the system has self-diagnostic functions with an auto-adjustment function of transmission skew. Consequently, the developed system will provide a full range of automation of the microearthquake observation and minimize the running cost for its long term operation. 1 ref., 4 figs.

7254 (GRSJ–8901, pp. 119-120) **Geothermal resources of Takigami field in Oita prefecture, Japan.** Furuya, S. (Idemitsu Geothermal Co., Ltd., Tokyo (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This paper describes the geologic structure and the geothermal system of Takigami district in relation to geothermal resources. From stratigraphical viewpoint the author recognizes the following three units; late Pleistocene volcanic rocks, early Pleistocene volcanic rocks and Tertiary rocks. A remarkable fault with NS strike and large downthrow on the west side of it occurs, dividing this area into two parts. From hydrological viewpoint the author divides the above geologic series into three layering units as follows; permeable top layer of uncompacted fresh volcanic products, impermeable second layer hydrothermally altered, and third layer of geothermal reservoir. Because of the impermeability of the second layer Takigami area has no surface manifestation. Marked difference in depth and fluid temperature is noted between the geothermal reservoir of the eastern side of the fault and that of the western side. 1 fig.

7255 (GRSJ–8901, pp. 121-123) **Application of reservoir engineering to Takigami geothermal field, Oita prefecture, Japan.** Shimada, T. (Idemitsu Geothermal Co., Ltd., Tokyo (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The downhole pressure monitoring during the well testing has come to be applied to the reservoir evaluation in geothermal field, which is however difficult, because of its hydrologically anisotropic and heterogeneous condition. The pressure monitoring is useful to overcome that difficulty. Idemitsu Geothermal installed, in Takigami geothermal area, Oita Prefecture, in 1984, a pressure monitoring system with capillary tubing, which has been successfully collecting numerous reservoir pressure data. Those data were analyzed to obtain the detailed permeability distribution, useful to the withdrawable reserve estimation and well allocation study for the exploitation. Through different studies, Takigami reservoir was proved to have potential to supply geothermal fluid enough to run a 55MW power plant. As for the application to reservoir evaluation, simulation models, comprising analytical pressure transient, lumped parameter and discrete parameter models, were described in this paper, about how to be supported with pressure monitoring data as a calibration method. For the pre-exploitation field, the analytical and discrete parameter models are to be used for the evaluation. However, the selection of model to be used to a specific field is to be carefully made. 2 figs.

7256 (GRSJ–8901, pp. 124-127) **Thermal groundwater in deep stratified reservoirs in Oita Prefecture, Japan.** Kitaoka, K. (Kyoto Univ. (Japan)); Kikkawa, K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This paper reports on an attempt to explain the distribution of subsurface temperature in the Oita plain by means of a simple model. In the district the underground temperature increased linearly with

depth at the rate of 5-7 deg. per m, and temperature deviation from the average value of the plain at each depth is at most about 7.5°C Taking several other evidences into account, a simplified model to explain these features is presented by the authors, which assumes slow upward flow of groundwater stored within thickly stratified formations through a vertical fault. Based on mathematical formulation of the model, the authors conclude that parameter μ, that is the square root of the ratio of horizontal permeability to vertical one, plays a significant role in controlling subsurface temperature. In the case of Oita plain, the large value of μ does not permit the temperature of upflow fluid to rise so high as in geothermal areas. 8 figs.

7257 (GRSJ–8901, pp. 132-135) **Geologic model of the Ginyu reservoir in the Kirishima geothermal field southern Kyushu, Japan.** Goko, K. (Nittetsu Mining Co., Ltd., Tokyo (Japan)); Miyashita, A.; Abe, I. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The Ginyu area, through the center of which the Ginyu fault provides a high angle passage for the geothermal fluid moving from a deep reservoir, is an active geothermal zone in the Kirishima geothermal area. For the exploration of the Kirishima geothermal area, 36 exploratory wells were drilled by Nittetsu Mining and Nippon Steel as well as the government, to confirm the existence of a dominant geothermal reservoir and reveal the geological and geothermal structure of the Ginyu area. Using such items as geological sections, electrical and temperature logs, and drilling logs from all the wells, a predominant geologic model was developed. The features of geothermal resources are of a typical fracture type, having several parallel subfaults, some of which are, with numerous lineaments and rapidly decreased ground isotherms, to be recharging zone faults, temperaturewise directed to the Kirishima volcano. The present activity is presumed to represent the post volcanic action of volcano having recently extruded. In the Ginyu production area, the feed points are uniform in temperature of 232°C, postulating the existence of a high permeable reservoir of meteoric water falling within the Kirishima graben. 4 refs., 6 figs.

7258 (GRSJ–8901, pp. 136-139) **Geochemical studies of the Ginyu reservoir in the Kirishima geothermal field.** Shimizu, A. (Nippon Steel Crop., Tokyo (Japan)); Misu, S.; Goko, K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This is a result presentation of geochemical interpretation study, based on chemical analysis and isotope data of discharge water and steam, and surface water in the Kirishima geothermal area, where discharge water from the wells drilled is of a near-neutral pH Na-K-Cl-So_4 type, while discharge fluid is provided from the water-dominated hydrothermal system. The Ginyu fault reservoir fluid is possibly derived from meteoric water. In the western part of the Kirishima volcano, surface manifestations such as fumarol, hot spring and alteration zone, caused by the geothermal activity, are widely distributed. As an interpretation results, through 16 production exploration drills, four among which, penetrates into the Ginyu fault at depth level and are found to be especially productive. Therein, meteoric water, having penetrated to the Ginyu area and east of it goes down to the basement at depth level of the Shimanto group, flows toward the Ginyu fault reservoir, during the course of which, heat exchange and reaction of water and rock occur, for the chemical element finally to get to the values, as confirmed by the analysis of discharge fluid from the geothermal wells. For the precipitation to reach the Ginyu fault reservoir, it is assumed to have several decades. 6 refs., 6 figs., 2 tabs.

7259 (GRSJ–8901, pp. 140-143) **Reservoir simulation on the Kirishima geothermal field.** Hazama, Y. (Nippon Steel Corp., Tokyo (Japan)); Nagao, S.; Abe, I.; Monden, Y.; Nobumoto, R. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The Kirishima geothermal field was surface surveyed in geology, resistivity and surface temperature by the government and Nittetsu Mining. Then in 1978, Nippon Steel and Nittetsu Mining jointly explored the geothermal resources, based of which information, a simulation of natural state was repeatedly computed, by using a simulator developed by Nippon Steel, with the establishment of a geothermal structural model for the Ginyu area. That simulation can be used for the tri-dimensionally heterogeneous transient problem, not only of mono-phase water but also two-phase water/stream. As a result of repeated simulations in the natural state, by using the measured data as an initial condition, an appropriate reservoir model, where the temperature and pressure became stable at the early stage of calculation, was established. The result of simulation, for three years of the actual reinjection by reservoir model, showed a good agreement with the observed data to prove it in validity. The simulation, using that model, to estimate the optimum production, suggested that steam production equivalent to 35MW of power generation could be secured for more than 30 years in the Ginyu area. 10 figs.

7260 (GRSJ–8901, pp. 144-147) **Modeling study of the natural state of the Kirishima field.** Maki, H. (New Energy Development Organization, Tokyo (Japan)); Ishido, T.; Abe, I.; Nobumoto, R.; Oikawa, Y. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In this paper the natural state of the Kirishima field is studied, using three-dimensional unsteady geothermal reservoir simulators developed by NEDO (New Energy Development Organization). The authors require in testing the model that the natural state should be itself a nearly steady solution of the governing equations for flow in the reservoir. The permeabilities of the rocks in the computational grid and parameters designating the boundary conditions are systematically varied during matching process. Starting from arbitrary initial state, interactive calculations are carried out for a total computed history of 20,000 years long. By about 10,000 years, most of the changes take place, thereafter the system evolves only slowly. The distribution of computed temperature and pressure fairly well reproduces the observed one. Furthermore, the pressure history for three years under interference test computed on the basis of the final natural state is in fairly good agreement with the one in observation well. 4 refs., 5 figs.

7261 (GRSJ–8901, pp. 148-151) **Modeling study of natural state of the Sumikawa field.** Maki, H. (New Energy Development Organization, Tokyo (Japan)); Ishido, T.; Kubota, Y.; Maeda, T.; Ariki, K.; Nakai, T. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This is an interim report on the modeling study of the natural state of Sumikawa field, Japan, using three-dimensional unsteady geothermal simulator developed by NEDO (New Energy Development Organization). Properties of rock formation were distributed spatially in accordance with the geological structure, and the permeability distribution was treated as a free parameter during the matching process. The parameters describing sources and sinks of thermal fluid, of which the initial state was entirely liquid, were somewhat adjusted during the development of the model. The best model so far developed reproduced observed temperatures and pressures reasonably well. But future refinement of the model is necessary, because substantial onvection and a temperature reversal appeared in the deepest layer of the model, which have not as yet been observed in well logs. In addition, this model cannot reproduce the observed pressure response of the interference test. 3 refs., 5 figs.

7262 (GRSJ–8901, pp. 152-155) **Subsurface pressure distribution the hydrology of the Sumikawa geothermal field.** Maki,

H. (New Energy Development Organization, Tokyo (Japan)); Pritchett, J.W.; Garg, S.K.; Kubota, Y. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This paper presents the subsurface pressure distribution in the stable natural state of the Sumikawa field. At shallow depths the subsurface pressure is approximated by P (bars) = 0.095 (D-35) for D>45, where D is depth in meters. Based on a number of shutin pressure determinations, the feed point pressure is formulated by P (bars) = 62.0 - 0.0776 Z, where Z is feed point elevation in meters. That is, deep reservoir pressure depends only one elevation with respect to sea level, and is independent of actual depth from the local ground surface. At intermediate depths pressure formula is modified so as to fit the well logs, thus attaining to overall pressure correlation consistent with the known facts about natural-state reservoir pressure in the area. Based on the subsurface pressure distribution, some tentative conclusions concerning the hydrology of the field is presented. 1 ref., 4 figs.

7263 (GRSJ–8901, pp. 264-267) **Behavior of fissure eruption of 1986 in Izu-Oshima as a geothermal heat source.** Hayakawa, M. (Tokai Univ., Tokyo (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In the time of the recent activity of November, 1986, in Izu-Oshima, not only the eruption of the central cone, Miharayama, but also there occurred fissure eruption trending NNW direction crossing the caldera rim. The author made gravity surveys at the last big eruption prior to the present activity in 1950. By the recent re-examination of these data, it became clear that some changes of gravity with time also appeared in that periods at the very place of the fissure eruption of 1986's activity. This fissure eruption of Izu-Oshima is seemed to be something similar to the fissure eruption on the eastern flank of Kilauea volcano, Hawaii. At the easternmost of Middle East Rift Zone of a famous geothermal well HGP-A of 1968 m depth was completed in 1976. This well has a production of about 3 megawatts of electric power. In the case of Oshima, it is expected that the background of geothermal structure being formed near the fissures under the ground. Some magnetic anomaly caused by thermal demagnetization has been discovered just over the southernmost fissure. At one of the wells at the northernmost area of the caldera wall, temperature of gas increased 5-6 C after the eruption of November, 1986. 9 refs., 10 figs.

7264 (GRSJ–8901, pp. 293-296) **Integration of earth-science data sets to estimate undiscovered geothermal resources in the Cascade Range, USA.** Muffler, L.J.P.; Guffanti, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The Cascade Range is a Tertiary and Quaternary volcanic arc, which is active with historic eruptions at different mountains. This paper cites, as references, totally 33 bibliographies up to 1988 edition, to variously explain approaching methods to estimate undiscovered geothermal resources in the Cascade Range, in which geothermal potential is indicated not only by the young volcanism, but also by a regional, positive and conductive heat-flow anomaly. Methods comprised therein are approaches through, among others, the elevated regional heat-flow expressed by sporadic thermal springs (summit-crater, caldera and lateral-flow systems), hydrothermal convection systems, volcano-tectonic setting multiplied the identified reservoir energy by a subjective factor, temperature-depth model, regional heat-flow and gravity cross section and transition zone, and thermal energy calculation for individual geothermal system. Resolution of the wide ranging resource estimates as well as the fundamental geothermal dichotomy can be addressed to the drilling and integrated interpretation of regional earth-science data sets. While hydrology clearly plays an important role in evaluating the three-dimensional thermal budget of Cascade Range. 33 refs.

7265 (GRSJ–8901, pp. 205-209) **Modeling of fluid and heat flow in fractured geothermal reservoirs.** Pruess, K. (Lawrence Berkeley Lab., CA (USA)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In most geothermal reservoirs large-scale permeability is dominated by fractures, while most of the heat and fluid reserves are stored in the rock matrix. Methods for modeling flow in fractured porous media must be able to deal with this matrix fracture exchange, the so-called interporosity flow. This paper reviews recent work at Lawrence Berkeley Laboratory on numerical modeling of nonisothermal multiphase flow in fractured porous media. A brief summary of simulation applications to problems in geothermal production and reinjection is given. Fluid and heat flow in fractured geothermal reservoirs involves complex phenomena operating on different space and time scales. These phenomena are characterized by highly nonlinear mathematical relationships. Flexible and robust simulation techniques have already given much new insight into the dynamical behavior of fractured reservoirs, and their response to production and injection operations. Practical applications have been limited by difficulties to adequately characterize fractured reservoirs over a wide range of spatial scales. Important effects such as porosity and permeability change from variations in pore pressures and rock stresses, and from chemical dissolution and precipitation of minerals, have not yet been adequately explored. There also is a lack of data on multiphase flow characteristics (relative permeabilities and capillary pressures) of real rough-walled fractures. If available, such data could substantially enhance the reliability and usefulness of numerical simulation predictions. 29 refs., 3 figs.

7266 (GRSJ–8901, pp. 210-214) **Reinjection into fractured geothermal reservoirs.** Horne, R.N. (Stanford Univ., CA (USA)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The movement of fluids through permeable rocks is a primary interest whether the fluid is groundwater, petroleum, geothermal steam, or radioactive or chemical contaminant. The first part of the paper describes the effects of individual fractures crossing a wellbore, while the second illustrates the effects of fieldwide heterogeneity on tracer returns. The consequence of the effects of the preferential flows are discussed in the third section. Geothermal reservoirs are by their very nature highly permeable formations of rock. In reservoirs of commercial interest, fluids are produced in very large quantities, and must flow at very high rates. It is not surprising therefore that almost all commercial reservoirs have major flow conduits within them. Based on drilling experience and on the results of tracer tests such as those described here, it is clear that faults and fractures provide the most permeable paths through the reservoir. That these paths provide short circuit routes for injected fluids to pass quickly through the reservoir is of great commercial significance. Many of the tracer returns have been easily correlated with faults previously recognized from geological mapping and from drilling records. 24 refs., 2 figs., 2 tabs.

7267 (GRSJ–8901, pp. 216-219) **Two-phase flow phenomena in a geothermal reservoir.** Shoji, T. (Univ. of Tokyo (Japan)); Hirakawa, S.; Obara, K.; Nakanishi, S.; Shinohara, N. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The fluid in a water-dominant geothermal reservoir is generally compressed water. When it is sent to a electric power station, it flashes in a reservoir or a well, and the fluid consists of two phases of vapor and water in the power station. The properties of the vapor

change as a function of the wellhead pressure as well as the reservoir pressure. Therefore, it is very important to control the wellhead pressure on the power generation process. The writers have examined the two-phase phenomena in the Onikobe geothermal field to know the relation between the wellhead pressure and the flashing point where the vapor forms its own phase in the geothermal fluid. Two geothermal reservoirs, shallow and deep, are recognized in the Onikobe geothermal field, both of them belong to the fracture type. The fluid for the powder generation is supplied mostly from the deep reservoir. It seems to be that the vapor is separated from the deep reservoir and trapped again at shallow levels. The pressure-temperature relation suggests that the fluid of the Onikobe geothermal field boils in the reservoir and flow into the production wells as two phase fluid. 3 refs., 8 figs.

7268 (GRSJ–8901, pp. 220-223) **On the behavior of two phase geothermal reservoirs.** Yano, Y. (Geological Survey of Japan, Tsukuba); Yasukawa, K.; Ishido, T. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Many geothermal reservoirs contain two-phase flow region under natural-state conditions. Vapor-dominated reservoirs are characterized by predominance of such regions, but even liquid-dominated reservoirs frequently contain two-phase regions which overlie part or all of the liquid filled volume below. Production-induced reservoir pressure decline will result in the growth of the two-phase flow region. Owing to compressibility effects, the response characteristics of two-phase regions and liquid zones are very different consequently, it is important to properly understand the development and flow characteristics of reservoirs containing two-phase zones. The purpose of this paper is to study the conditions required for the development of a two-phase zone in a typical Japanese geothermal reservoir. The complicated behavior of two-phase systems may now be treated using numerical simulation technique. It has been shown that an extensive two-phase region may form at the top of a geothermal reservoir even if the caprock is penetrated by a permeable fissure, so long as sufficient upflow of hot water from below is present. At exceedingly high upflow rates, the two-phase region will be relatively small in size, if the upflow rate is less, the two-phase zone will be more extensive. If, however, the upflow rate is less than a certain critical value, the two-phase region vanishes and cold-water downflow will occur through the fissure. Simple algebraic models may be used to estimate this critical upflow rate. 2 refs., 6 figs.

7269 (GRSJ–8901, pp. 228-232) **Integrated approach to conceptual modeling of geothermal reservoirs.** McNitt, J.R.; Robertson-Tait, A.; Klein, C.W.; Sanyal, S.K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Optimum use of a geothermal reservoir can be best achieved by using a conceptual hydrogeologic model of reservoir as a guide to development. The conceptual model defines the geologic structures and/or stratigraphic units which form permeable zones within the geothermal system, source of fluid and direction of flow within these zones, and location of reservoir with respect to the main elements of the geothermal system, including the upflow zone, outflow zone and heat source. A detailed and accurate conceptual model can only be developed by integrating and interpreting all applicable geologic geophysical, geochemical and engineering data. Although interpretation of data from each of these various disciplines is made by separate groups of individuals with appropriate expertise, all data must ultimately be compatible with one comprehensive model. Recognition of the inherent relationships between different types of data is crucial to the integrated approach. GeothermEx's experience with geothermal development worldwide has revealed several fundamental examples of data which are rarely integrated. All data must be integrated on both a regional and local scale in order to develop a valid conceptual model of geothermal reservoir and determine the relationship of geothermal system to the surrounding area. This conceptual model not only serves as a development guide, but forms the basis for a realistic numerical simulation model which can be used to determine the optimum production scenario for the geothermal field.

7270 (GRSJ–8901, pp. 234-235) **Occurrence of hot-water at the Nibetsu area , Akita, North Japan.** Akibayashi, S. (Akita Univ. (Japan)); Fukuda, M.; Ito, M.; Yamamoto, I. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

A hot-spring was detected at the Nibetsu area about 15 km northwest of the center of Akita city in 1987. Geology in this area is composed mainly of the volcanic rocks and their associated sedimentary rocks, and the basement composed of granodioritic and Tertiary granitic rocks is considered as a heat source in this area. From the results of radioisotope exploration, there are many points of bismuth concentration near the estimated faults and the lineaments, suggesting the possible presence of fractures which may be opened to the surface. The sedimentary beds strike N20 -40 W and dip westward, and the fracture zones also have the same strike direction with westward dipping. The amounts of the residue on evaporation per kilogram of the hot-water sampled from the depth of 550 m and 1000 m are 480 mg and 669 mg, respectively. These hot-water can be thought of a part of hydrologic cycle, including surface and meteoric water which infiltrated into the ground through the fractured zones. The hot-water velocity is estimated to become from 1.0 to 0.2 (m/day). ate. 3 refs., 8 figs.

7271 (GRSJ–8901, pp. 253-256) **Evaluation of geothermal heat source.** Tamanyu, S. (Geological Survey of Japan, Tsukuba). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Geothermal heat potential is generally evaluated by the activities of Quaternary volcanism. Smith and Shaw (1975) proposed an igneous-related geothermal system, which is famous for its quasi-quantitative evaluation of heat contents based upon the diagram of conductive cooling model of magma chamber. This method rests upon estimates of the probable volume of high-level magma chambers and determinations of the radiometric ages of the youngest volcanism, and is adopted to the Quaternary volcanoes in Japanese geothermal fields, such as Hofi, Semgan and Kurikoma areas. These results suggest that heat potentialities inferred from Smith and Shaw diagram seem to be underestimated for the middle Pleistocene volcanoes (radiometric ages of the youngest volcanism ca. 0.3 million years) of which magma chambers have been proved to play important roles in heat sources by many deep drillings. The present author tried to examine the two major assumptions of Smith and Shaw diagrams, which are (1) heat transfer in rocks surrounding the magma chamber is by solid-state condition and (2) effects of magnetic preheating and gains of magma after the time of the youngest volcanism are ignored. The assumption (1) is ignored because it works on the heat evaluation as the cause of overestimation. Whereas, the assumption (2) conversely affects as the cause of underestimation. Therefore, assumption (2) and other parameters, for example time lag for ascending propagation of heat anomaly which affect as the cause of underestimation should be examined. 6 figs., 1 tab.

7272 (GRSJ–8901, pp. 258-259) **Cooling of geothermal system and ESR dating.** Taguchi, S. (Fukuoka Univ. (Japan)); Morifuji, M.; Hayashi, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Cooling of geothermal system and the electron spin resonance (ESR) dating was described. Usually, we can detect several ESR

signals which were called OHC, E' and Ge centers respectively, from a quartz sample separated from the products of geothermal activity. The differences among the ESR ages indicate that the each ESR center has different thermal stabilities. Age of E' center is usually younger than the other ages. Also, the result of annealing experiment of the quartz sample shows that thermal stability E' center is weaker than that of the other centers. The ESR ages (in 10^6 years unit) for quartz samples were as follows. E' = 0, OHC = 4 and Ge = 7 for the Hishikari gold mine, E' =11, OHC = 28 and Ge = 24 for the Masaki area (located about 7 km to the north of the Hishikari mine) at low elevation, E' = 8, OHC = 50 and Ge = 61 for the Masaki silicified rock at high elevation. The OHC ages from the Masaki area is older than that of the Hishikari mine. This is partly due to the difference of the elevation of the place where the hydrothermal activities occurred; cooling effect by erosion. However, it is largely due to the hot spring activities with 65°C at Hishikari mine. On the other hand, large difference between the OHC ages at low elevation and at high elevation of Masaki area is probably due to the difference of the cooling by erosion, since the silicified rock is situated at the margin of the system and the topographically high elevation. As above mentioned, the ESR ages of the geothermal products are easily affected by the cooling of the geothermal system. Therefore, the difference of the each ESR age of a sample will be applicable to reveal a thermal history of a geothermal system. 4 figs.

7273 (GRSJ–8901, pp. 260-263) **Geothermal structure of Kurobe hot dry rocks, central Japan.** Nishimura, S. (Kyoto Univ. (Japan)); Mogi, T. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

During the construction of the tunnel of Kurobe Jobu Railway, the temperature in the tunnel increased and at last reached over 160°C of wall rock temperature. There were not so many hot springs and fumaroles in the tunnel. Therefore, the rock body is considered to be hot dry rocks with residual heat. Temperatures of the wall surface show 98°C at the maximum even now, and their high values correspond to a fracture zone of the rock body. Combining the survey and studies, several conclusions were drawn. Low resistivity layers are found at depths of less than 300m beneath the surface. Some hot-springs are found along the Kurobe River and these reservoirs are shallow, having sheet-like structures. The chemical geothermal results obtained from the hot-springs give the temperature of 160-180°C at the source. From these results, the temperature of the central part of the Kurobe granitic body is estimated as 200-250°C. The K-Ar ages of the granitic rocks around the Kurobe geothermal area have close relation to the altitudes of sampling sites. From mathematical interpretation of this relation, the cooling history of this granitic body can be inferred. 5 figs.

7274 (GRSJ–8901, pp. 274) **Application of volcano-geological parameters in geothermal exploration. Philippine experience.** Alcaraz, A. (PNOC-EDC, Manila (Philippines)); Datuin, R. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Large scale utilization of geothermal energy has been carried out in several areas where anomalously large heat fluxes occur. These anomalous areas generally coincide with the boundaries of the earth's tectonic plates along which volcanism and seismic activity are abundant. Not surprisingly, therefore, the most favorable areas for the exploitation of geothermal energy are characterized by volcanic and earthquake activity. The Philippines enjoys such a locale. The use of volcano-geology, therefore, as a goal for geothermal exploration and development is emphasized in the paper.

7275 (GRSJ–8901, pp. 275-276) **Using of geothermal energy in the deep sedimentary basins in the USSR.** Sardarov., S.S. (Inst. of Geothermic Problems, Makhoachkala (USSR)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The using of geothermal energy in the deep sedimentary basins in the USSR was described. The industrial exploitation of the depth heat was begun in the USSR in 1966. Geothermal objects can be easily subdivided into three groups such as convective magmatic systems, convective hydrothermal systems (CHS) and petrothermal systems (hot impermeable rocks). In deep sedimentary basins a CHS-like geothermal object is attached to a fault. The conditions of heat-and mass transfer within and without a disjunctive differ greatly. Of principal interest is the area of the dynamic influence of the disjunctive (ADID) in which deformation caused by the disjunctive development are manifested. The ADID is always a higher permeability zone. In natural conditions, disjunctives are covered with a practically undisturbed layer of modern sediments, and the ADID body is saturated with fluid (water, gas, oil). Thus in the case of CHS the canal of the extraction can be calculated for quick upraise of great volumes of hot brines from the depth of 3 to 6 km. Thermal waters contain strontium, arsenic, naphthenic acids. Quite typical are in thermal waters hydrogen sulfide, iodine and boron compounds. Geothermal activity influence on the environment may give rise to new probiems. The complex deep reprocessing of geothermal resources with back pumping is capable of solving the problem, but back pumping to the depth of 3-4 km raises a number of technical problems.

7276 (GRSJ–8901, pp. 277-282) **Geophysical structure of the Broadlands-Ohaaki geothermal field (NZ). Case history of exploration.** Henrys, S. (Univ. of Auckland (New Zealand)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

During the past decades most of the known hot-water geothermal systems in the Taupo Volcanic Zone (TVZ) have been explored by geophysical techniques. The Broadlands-Ohaaki geothermal field, located on the eastern margin of the TVZ, is one of the thermal systems delineated by these surveys. The extent of the Broadlands-Ohaaki field was first outlined by resistivity measurements in 1965. Between 1968 and 1970 detailed seismic refraction, gravity and magnetic surveys were undertaken to determine detailed structural features within the field. Since 1970 stratigraphic and rock property data from additional wells have become available and the acquisition of common-mid-point seismic reflection data in 1984 has provided better correlation of the volcanic stratigraphy and established a more accurate velocity model for the geothermal field. This paper has shown that an integrated analysis of seismic reflection and refraction data and of gravity and magnetic anomalies can give a very detailed picture of a hot-water reservoir. The structures elucidated in this study do no not effect the siting of future production wells, since production drilling is nearly complete. Although, it is likely that the structural details outlined will supply additional information for assessment of productivity and monitoring. 9 refs., 2 figs.

7277 (GRSJ–8901, pp. 283-286) **Atlas of geothermal resources in the European Community, Austria and Switzerland.** Haenel, R. (Geological Survey of Lower Saxony, Hannover (Germany, F.R.)); Staroste, E. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The Atlas of the commission of the European Communities is one the major achievements of the Community's Geothermal Energy Research and Development Programe, and represents the results of work in many countries over several years and is the first attempt in the world to present comparable data on geothermal resources both within and across national borders. The Atlas, consisting of 110 plates representing more than 400 maps, is a fundamental document for the exploration of geothermal energy. The first 5 plates of the Atlas give a general view of the results acquired on a European

scale and represent the geodynamics and geothermal perspectives, the heat-flow density, the temperature at 1000m depth, the temperature at 2000m depth and a review of geothermal resources based on available information including all geothermal installations at present operational or under construction. They are followed by more than 100 plates on national or regional scale representing mainly the essential characteristics for each aquifer, such as depth, thickness, temperature and-as far as possible-porosity, permeability, transmissibility and salinity. 2 figs., 1 tab.

7278 (GRSJ–8901, pp. 339-342) **Intrusion of geothermal water into domestic groundwater in Chiang Mai basin, Northern Thailand.** Ratanasthien, B. (Chiang Mai Univ., Chiang Mai (Thailand)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The similarity in chemical species of some domestic groundwater in the eastern part of Chiang Mai basin and thermal spring water were noticed during the investigation for the cause of fluorotoxicosis in Northern Thailand. The major elements except silica such as sodium, fluoride, calcium, magnesium and iron are showing the same trend and against those of normal groundwater. The effect areas located parallel to the Mae Tha fault zone and show the direction intercept with thermal spring system. The intrusion of thermal water into these domestic groundwater were suggested via underground fractures and faults which related to the thermal spring system. The isotopic study show the contaminated water have their isotopic ratio trending toward the thermal spring water indicated the origin of these water similar to those of thermal springs but at a lower mixing ratio. The relationship between the groundwater in the eastern part of the basin with the San Komphaeng geothermal system are strongly structural controlled as suggested by faults and the fluoride ion contamination in the domestic groundwater. 3 refs., 3 figs.

7279 (GRSJ–8901, pp. 398-401) **Development of low-temperature geothermal reservoirs for commercial power. U.S. experience.** Sanyal, S.K.; Koenig, J.B.; Robertson-Tait, A.; Menzies, A.J. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Low-temperature geothermal resources are defined herein as those reservoir temperature less than 200°C. This paper reviews the experience of the U.S. geothermal industry in the development of electrical power projects. Low-temperature geothermal systems in the U.S. are found within two physiographic provinces: the Basin and Range in Nevada and Utah and the Salton Trough in California. Magmatic heat sources are not directly associated with the majority of these systems. Temperature in these systems range from approximately 105°C to a high 200°C. Fluids within most of this range of temperature are typically used in binary cycle geothermal power plants. Some systems support flash steam generation and rotary two-phase turbine generation. The systems which are used for binary generation have a large range in temperature (104°C to182°C). Well drilled into these systems are typically shallow (200m to 1800m) and downhole pumps are after used to maintain a suitable flow rate and enthalpy at the wellhead. Modular binary generating units are used for many of the projects. A total of approximately 260 MW of power capacity based on low temperature geothermal system is on-line or under construction in the U.S., and the estimated undeveloped capacity is several thousand MW. 1 tab.

7280 (GRSJ–8901, pp. 302-303) **Modeling of deep temperatures and heat flow in entral Honshu, Japan.** Bodri, B. (Eoetvoes Univ., Budapest (Hungary)); Iizuka, S.; Hayakawa, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The results of numerical study of the distribution of deep temperature and heat flow at depth in Central Honshu, Japan, are presented. Due to complicated geological-structural characteristics of crust and specific plate tectonic features of lithosphere, this area has extensively been investigated by different methods for decades. The calculation of deep temperature and extrapolation of heat flow to depth were carried out on basis of numerical solution of a two-dimensional steady-state equation of heat conduction in a heterogeneous medium. The finite difference analogue of this equation was solved on a rectangular grid with uniform zones, applying a successive over-relaxation technique. Heat flow at depth exhibits large variations. In zones of low surface heat flow the temperature at Moho amounts to 350-500°C, whereas it may reach 800-1000°C in areas of high heat flow anomalies. Regional variations in Moho heat flow range from 15-20 to 40-50 mWm^{-2}. The results definitely suggest the existence of asthenoshpere at depth as large as 50km in zones of heat flow. A comparison between the features of distribution of deep temperatures and those of variations in other geophysical characteristics (Curie-point depth, electrical conductivity, seismicity, seismic velocity perturbation, seismic attenuation) has also been made. In some cases good correlations were found. 6 refs.

7281 (GRSJ–8901, pp. 304-306) **Characteristics of geotemperature field and the tectonics of crust and upper mantle in eastern China.** Jin, X. (Changchun College of Geology, Jilin (China)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Almost active hydrothermal areas distribute in the epicontinental region of Dashinganling-Taihangshan-Wulingshan gradient zone of gravity in Eastern China, and the water temperature is intermediate or low. The gradient of geotemperature in the sedimentary blanket falls with increasing in basement depth. The temperature profile corresponds to the relief of basement. As a whole, the temperature distribution of the geotemperature field in Eastern China has an increasing trend from the north to the south and from the west to the east, From statistical analyses of the geophysical data in Shungliao plain, Huabei plain and Jianghan plain it is clear that the geothermal anomalies closely relate with the basement relief. In recent years, many researchers calculated the depth of Curie temperature by using the materials of aeromagnetic survey in some regions. On both sides of the Tancheng-Lujiang fault system disparity in the depth of Curie temperature is about 5-7 km, and in the west side is deeper than that in the east side. This characteristic feature just corresponds to the fact that the heat flow in the east side is higher than that in the west side. 6 figs., 1 tab.

7282 (GRSJ–8901, pp. 307-309) **Thermal regime of the upper continental crust of the Exmouth Plateau region, offshore northwest Australia.** Swift, M.G. (Bureau of Mineral Resources, Geology and Geophysics, Canberra (Australia)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The Exmouth Plateau is a submarine marginal plateau with an area of about 150,000 km^2 situated off the northwest Australian continental margin. The plateau consists of deeply rifted and subsided continental crust. At its crest, the plateau is 800 m below sea level and sedimentary thickness, consisting of pre-breakup Paleozoic to early Mesozoic sediments and post-breakup Mesozoic and Tertiary sediments, are up to 10 km. In 1986, an extensive set of 41 marine heat flow values over the Exmouth Plateau were found. A further 58 heat flow stations were occupied in early 1987. The overall average heat flow values for the region is 56 MW/m^2, however the points of interest in the heat flow pattern are: the area of low heat flow (as low as 17 MW/m^2) in the center of the plateau together with the heat flow high (as high as 100 MW/m^2) to the east on the shelf, and the lack of any heat flow anomalies associated with the margins. In conclusion, the thermal structure of the upper

crust on the Exmouth Plateau is characterized by a major redistribution of heat producing elements to basement level. 5 refs., 2 figs.

7283 (GRSJ–8901, pp. 310-312) **Subduction of the Juan De Fuca plate and heat transport.** Lewis, T.J. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Terrestrial heat flux was measured in fjords, in boreholes and in offshore wells at sites across the convergent margin of southwestern British Columbia from the continental shelf landward to the Garibaldi Volcanic Belt. Temperatures in the offshore wells were corrected for drilling disturbances, and formation thermal conductivities were modeled using measurements on cuttings and downhold geophysical logs. These measurements were combined with previous ones, and there was excellent agreement between marine measurements and those from nearby onshore boreholes. The heat flux above the subducting Juan de Fuca plate steadily decreases landwards from over 50 mWm^{-2} on the shelf to 25 mWm^{-2}seaward of the Garibaldi Volcanic belt. An abrupt increase to 80 mWm^{-2} over a distance of 200 km is centered 300 km seaward of the volcanic zone. A landward dipping, above the subducting oceanic plate beneath Vancouver Island appears to be nearly isothermal. This layer is also the top of a low electrical resistivity zone. 5 refs., 3 figs.

7284 (GRSJ–8901, pp. 313-316) **Heat flow and hydrothermal circulation in the Okinawa Trough.** Yamano, M. (Univ. of Tokyo (Japan)); Kinoshita, M.; Uyeda, S.; Post, J. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The Okinawa Trough is in a stage of rifting of continental lithosphere, and there is a possibility that sea floor spreading has started in the very axial region of the southwestern part of the trough. Thus, the trough is thought to be thermally active and hydrothermal circulation may be taking place. In 1984, 1987 and 1988 detailed heat flow measurements were carried out in the Okinawa Trough, and geothermal studies have been also made using the Japanese submersible boat Shinkai 2000 since 1986. In this paper, the most up-to-date heat flow distribution in the Okinawa Trough were presented and the hydrothermal circulation and the thermal structure of trough inferred from the heat flow data were discussed. In the middle Okinawa Trough several thermal anomalies were detected. High heat flow anomalies may extend in the east-west direction parallel to the trough axis, and an extremely high heat flow anomaly was found in a small depression surrounded by small knolls. Such high heat flow anomalies can be explained to be caused by volcanism with the rifting process of lithosphere. 10 refs., 4 figs.

7285 (GRSJ–8901, pp. 317) **Thermal springs in the Republic of Korea.** Lim, Jeong Ung (Korea Inst. of Energy and Resources, Seoul). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In the Republic of Korea, there are 24 thermal springs ranging water temperature between 24°C and 78°C and 40 mineral springs. These thermal springs are developed for bathing and resort facilities. Total amount of daily use of thermal water from those springs reaches up to 30,000 cubic meters, resulting the groundwater table lower about 100m below the surface in most cases. Most of these springs are found in the central part and southeastern part of the peninsula, coinciding with the structural line of NE or NNE direction. The Cretaceous granite is the main host rocks with some Tertiary volcanic outcrops. Thermal springs are densely populated along the fault line of NNE. The heat flow unit in this region ranges higher than 2.0 HFU throughout the country. Thermal gradient averages 2.5°C/100m but increases up to 5.0°C/100m at Pohang within a measurable depth up to 500m, which can be expected to reach the water temperature higher than 100°C at the depth of 2,000m.

7286 (GRSJ–8901, pp. 318) **San Kamphaeng geothermal field.** Thienprasert, Amnuaychai; Raksaskulwong, Manop; Surinkum, Adichat. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

San Kamphaeng geothermal field is one of the most promising and extensively studied areas in Thailand. Geological studies at scale 1/10,000 indicate that the area is composed of the oldest Mae Tha Formation of Carboniferous, Kiu Lom Formation of Middle Permian, granites and andesites of triassic and alluvial deposits. The area is a horst-and-graben type bordered by normal faults, the Huai Pong fault and the Huai Mae Koen fault, trending in the NNW-SSE direction. Chemical alteration zones of outcrops indicate that hydrothermal solution causing the alteration is possibly and intermediate-to-acidic liquid of less than 200°C temperature. Seismic studies indicate that the faults along the hot spring area and adjacent are still active and the geothermal fluids circulate and upflow along these conduits to the surface. In conclusion, the potential geothermal area in the San Kamphaeng geothermal system is confined to Ban Pong Nok District, where actual manifestations are found on the surface and N-S and NW-SE trending faults are perceived.

7287 (GRSJ–8901, pp. 319-321) **Thermal state and hydrology of the Byelorussia and adjacent areas.** Zui, V.I. (Inst. of Geochemical and Geophysicals, Minsk (USSR)); Parkhomov, M.D. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The terrestrial temperature field in the western part of the Pre-Cambrian East-European Platform on the territory of Byelorussia and adjacent areas is nonuniform. At the background of low heat flow density values 20-40mW/m^2, the positive anomalies are clearly distinguished, where 70-80mW/m^2 values are observed in the area of the Baltic Syncline and the Pripyat Trough. The upper part of platform sedimentary cover is subjected noticeably to distortion of observed heat flow density values mainly due to ground-water movement. The most favorable areas from the point of geothermal energy, thermal waters and brines utilization are deep sedimentary basins: the Central part of the Baltic Syncline, the Pripyat Trough, and the Dnieper-Donetz Depression. Waters of Above-Salt deposits of the Pripyat Trough and some aquifers of the USSR part of the Podlyasie-Brest Depression, as well as the Moscow and the Baltic Synclines are low-enthalpy ones. Their utilization is possible mainly by means of heat pump technique application. 8 refs.

7288 (GRSJ–8901, pp. 322-325) **Temperature structure under the Japan arc estimated from measured heat flow values and radioactive heat generation.** Furukawa, Y. (Univ. of Tokyo (Japan)); Li, S. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In this paper, radioactive heat generation and hydrothermal water circulation in the crust taken in account, and thermal structures in the crust and in the shallow part of the mantle under the arc are estimated by using the data of heat flow measurements and heat generation values. Radiogenic heat generation values of rocks in the arc was measured on INAA and gamma-ray spectrometry in this study. Two-dimensional temperature structures in some profiles across the arc were calculated to estimate the cooling effect of subducting slab. It was clarified that lateral temperature variation by subduction is significant. There was good agreement between heat flow pattern and seismic velocity perturbation in the depth of 16-17 km. Low and high temperature anomalies coincide with subducting slab and active regions of volcanism respectively. Extension and intensity of temperature anomalies caused by such tectonic and geologic activities can be estimated in this study. 6 refs., 4 figs.

7289 (GRSJ–8901, pp. 334-337) **Low to medium temperature thermal water resources in North China basin.** Xiao, Deng (Inst. of Geology, Beijing (China)); Mo-Xiong, Chen; Ji-Yang, Wan; Jun, Wan. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

North China Basin is rich in geothermal resources, and is the most prospective area for the exploration of low or medium temperature thermal water. There are aquifers of Neogene formations and thermal water in carbonate strata. The former is featured by extensive distribution, shallow occurrence and low water salinity, and about 500m in depth and 30-80°C in water temperature. The latter contained in buried hills is controlled by the development and distribution of karst, and 50-100°C in water temperature. The latter estimations in respect to a thermal water resource are as follows: $19X10^3km^3$ in the total volume of buried hill geothermal water fields, 30% in the ratio of a reservoir to a buried hill volume for the reservoir of mid-upper Pt, 20% for low Pz, 5% in the mean porosity of the reservoir for the section from the hill top to 500m depth, 3% for the deeper section, $180X10^9m^3$ in the volume of thermal water stored in the buried hills, and $45X10^9m^3$ in recoverable resources. The estimation obtained from both Neogene and buried hill aquifers corresponds to $900X10^6$tons of standard coal. 4 refs., 4 figs.

7290 (GRSJ–8901, pp. 338) **Basic characteristics and origin of Zhangzhou geothermal field, Fujian Province, SE China.** Wang, Ji-Yang (Lab. for Geothermics, Beijing (China)); Pang, Zhong-He; Xiong, Liang-Ping; Fan, Zhi-Cheng. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Zhangzhou geothermal field is the highest in temperature one so far discovered in coastal area of SE China. The highest temperature measured at the well-head exhibits 106°C and 121.5°C at the bottom of a drill hole of 90m depth. The flow-rate of an artesian well in the central part of the field may reach 500 tons per day. Two sets of faults are obvious in Zhangzhou geothermal field, namely they are NNE, NWW and NE, NW respectively. The regional distribution of thermal water is controlled by these two fault sets. Chemically, thermal water of the field is characterized by the high Cl content which is resulted from the mixing with the sea water. Oxygen and hydrogen isotope studies indicate that thermal water originally comes from the meteoric water. The recharge area seems to be the Tian-bao Mt. in the NW direction of the field. The basement rock (granite) of the field is high in U, Th contents and thus, in addition to the heat from the depth of the Earth, the radiogenic heat from the upper crust may contribute a large amount of heat to the field.

7291 (GRSJ–8901, pp. 413-416) **Some recent developments in geothermal reservoir engineering in New Zealand.** McGuinness, M.J. (D.S.I.R, Wellington (New Zealand)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Some recent development in geothermal reservoir engineering in New Zealand were described. Ngawha geothermal reservoir material is predominantly fractured greywacke, heavily faulted, overlain by up to 500 m of low permeability breccias. Fluid temperatures are typically 220 - 230°C in the main permeable region, and is mostly single-phase liquid. The pressure transients of the observational wells were observed to both production and injection. The responses of observational wells were rapid and identical. Simple approximate approach leads to the solution, assuming the volume flow rate change at a source well, the total reservoir volume, the porosity of the fracture system, the porosity of the rock matrix, the rock permeability and the average thickness of the rock matrix. When this solution is fitted to pressure data, much closer fits are obtained. Kawerau is more typical of New Zealand geothermal fields. It consists of basement graywacke overlain by poorly correlated volcanic sequences. The reservoir fluid is about 280°C and is mostly single-phase. High permeabilities are evident. A heat-sweep computer model of the Kawerau geothermal field has been constructed. Fluid is taken to flow through a fracture system, exchanging heat with adjacent rock by conduction, and taking recharge to be mainly from the sides of the reservoir instead of from above. The computer model is useful. Cooling problems are with poor sealing off of cooler shallow feeds, allowing cool shallow waters to enter the well. 2 refs., 7 figs.

7292 (GRSJ–8901, pp. 499) **HDR investigations down to 400m depth in crystalline rocks at Falkenberg.** Kappelmeyer, O. (Geothermik Consult GmbH, Duesseldorf (Germany, F.R.)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In a granite massif in NE Bavaria/FR Germany in depth range down to 400m an artificial heat exchange system with an extension of more than $25000m^2$ was stimulated by hydraulic fracturing. Six additional boreholes, which intersected the stimulated fracture, provided access to the fracture system at different distance between injection point and extraction point during circulation and allowed systematic experimental investigations on an thermal behavior at various pressure stages. The following results were obtained: fracture width, fracture transmissivity and fracture volume changed nonlinearly with fluid pressure, and the nonlinear relationship between fracture width and fluid pressure was explained by a model describing the deformation of asperities on the fracture surfaces; the observed relationship between pressure drop and flow rate was explained by assuming a turbulent region around the boreholes, and due to this turbulent energy losses much higher fracture transmissivity was needed to operate a hot dry rock system than was calculated from laminar flow models; the water losses at stationary conditions increased linearly to the fluid pressure within the fracture.

7293 (GRSJ–8901, pp. 461-464) **Seismic activity and thermal process beneath the Kuju-Iwoyama Fumarolic area, Central Kyushu, Japan.** Ehara, S. (Kyushu Univ., Fukuoka (Japan)); Bito, T.; Oi, T.; Kasai, H. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In this paper, a thermal model to satisfy the observed thermal and seismological data beneath the fumarolic area, Central Kyushu, Japan was proposed. In this model, the magmatic steam of 30 kg/s (enthalpy 3500 kJ/kg) is supplied from the depth of 2km. This is the steam which has the pressure of about 15 MPa and the temperature of about 580°C. This steam mixes with the meteoric water of about 10 kg/s and finally the steam of 35.8 kg/s and the hot water of 4.4 kg/s are discharged at the surface. The natural heat discharge is 104.4 MW. The temperature of the first layer (0-250m depth) at the central part is about 210°C. The temperature in the bottom layer (1750-2000m) exceeds 340°C. The central high permeable zone is in a state of two phase at any depth. Outside the central part (e.g. recharge area), the heat transfer is mainly by conduction. And the pressure distribution is nearly hydrostatic. But in the central permeable part, the pressure is a little higher than the hydrostatic one. The high pressure in central part (high permeable zone) may become an origin of the high seismic activity in this part, since the high pore pressure lowers the strength of rocks. The production rate is 30 kg/s of the hot fluid in the second layer (250-500m depth) in the central permeable part, which is comparable to 10 MW power generation. 9 refs., 6 figs.

7294 (GRSJ–8901, pp. 434-437) **Some results from Continental Scientific Drilling Program Core Hole VC-2A, Valles Caldera, New Mexico, USA.** Goff, F. (Los Alamos National Lab., NM (USA)); Gardner, J.N.; Hulen, J.B.; Nielson, D.L. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy,

Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The VC-2A is a scientific drilling program core hole, designed to investigate the magma-hydrothermal system of Valles caldera, resurgent cauldron in the northern part of New Mexico. The VC-2A was, in the primary objective, to penetrate the vapor cap rock at the top of liquid-dominated hydrothermal system. And it was in the secondary objective, to study the resurgence mechanism near the structural intersection between the western ring-fracture zone and resurgent dome, and ore deposit formation mechanism in the large silicic caldera. Finally it was, in the technical objective, to obtain the continuous core by reaching the depth of 500m and temperature of 200°C. The hydrothermal system at the sulfur spring is merely a present subsystem within Valles caldera, where hydrothermal activity has been continuously occurring for these one million years, without the significant change of deep reservoir fluid in composition. However, the Mo deposit, confirmed in presence by the VC-2A, indicates that a major hydrologic change have occurred in the hydrothermal system. 16 refs., 4 figs., 1 tab.

7295 (GRSJ–8901, pp. 402-403) **Geothermal resources of India. Scope and future utilization.** Dubey, C.S. (Univ. of Delhi (India)); Singh, S.K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Geothermal resources discovered in India consist of warm/hot water systems. The main geothermal manifestations are distributed in four areas viz: (1) a continental collision zone: Himalayan region, (2) marginal depressions: Himalayan foredeep,(3) coastal areas and (4) Peninsular shield areas. Geochemical and geophysical surveys are indicative of high temperature, high heat flows and low resistivity zones in Puga Manikaran and the West coast geothermal area. At shallow depths medium temperature waters and reversal of temperature are very common. The mountainous terrain, negative temperature gradient at the bottom and presence of travertine deposits of borax and sulphur distributed at different sites indicate that the above geothermal areas under exploratory drilling are that of lateral outflows of geothermal fluids away from upflow centers. To the south of Puga valley, very low resistivity zones have been recently located but it is difficult to do exploratory drilling in this area due to unruly topographic conditions.

7296 (GRSJ–8901, pp. 407-409) **Aspects of exhaustion and declination of thermal spring resources in Obihiro urban district, Hokkaido, Japan.** Doi, S. (Hokkaito Inst. of Tech, Sapporo (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This paper described the aspects of exhaustion and declination of thermal spring resources in Obihiro urban district, Hokkaido, Japan, which have been developed since 1976. As a result, by the end of 1987, the orifices of thermal water already dug out numbered 27, of which 22 orifices are currently in use. Orifices are between a depth of 1100 to 1650 m. As the number of orifices increases, for example, in the case of the orifice of Romanoizumi, the thermal water level declined by 76 m during the 2 years period. Furthermore, as the thermal water level lowered, the amount of gush of thermal water dropped from 468 l/min to 331 l/min. During the same period, the thermal water temperature also decreased from 45.0 down to 44.1°C. Moreover, judging from the sea level distribution of the thermal water of existing orifices measured at Obihiro urban district during the period of 7 months, a 1 to 2.5 m decline of the thermal water level was observed. On the other hand, the amount of gush per orifice was 614 l/min in 1980 and 311 l/min in 1986, respectively. Furthermore, with the decrease in the amount of gush, the thermal water temperature dropped at every orifice, with the maximum temperature drop being 8°C. As countermeasures, it is necessary to continuously monitor the amount of gush, thermal water temperature, isopotential level, and shut-in pressure. In addition, 2 to 3 observational wells should be drilled to investigate the aquifers level. On the basis of these data, an decision of the subsequent development plan should be made. 4 refs., 2 figs.

7297 (GRSJ–8901, pp. 410-412) **Geothermal pre-feasibility study in Phetchanbun area of Northern Thailand.** Singhasenee, C. (Chiang Mai Univ., Chiang Mai (Thailand)); Ramingwong, T.; Lerdthusnee, S.; Uttamo, W.; Suvagondha, F.; Wattananikorn, K.; Jurasai, L. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Four hot spring areas, located at Ban Nam Ron, Ban Pu Toei, Ban Pu Kham and Ban Wang Kham are to be found in Phetchabun province, approximately 350 km northeast of Bnagkok, Thailand. The surface temperature range from 35-47°C with generally small discharges. The Phetchabun geothermal system is principally a fracture-controlled system and is classified as a low-enthalpy system with subsurface temperatures at around 120°C. The potential uses are therefore restricted to direct uses. Socio-economic factors become the main criteria used in selecting the highest potential geothermal system for further drilling programs. Pu Kham hot spring, as the most easily accessible, densely populated, and with its easy availability of agricultural products, is considered to be the most viable for exploration drilling to a proposed maximum depth of 100 m. The proposed exploration well should encounter hot water upflowing along fractured zones at a depth of not more than 100 m. 4 figs.

7298 (GRSJ–8901, pp. 418-421) **Results of NEDO's development of Geothermal reservoir evaluation technology program.** Maki, H. (New Energy Development Organization, Tokyo (Japan)); Kawano, Y. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The results of NEDO's (New Energy Development Organization) development of geothermal reservoir evaluation technology program were described. In each field, single-well pressure transient tests are performed to obtain information concerning the reservoir permeability distribution and locations and type of reservoir boundaries. Numerical natural state reservoir simulations and carried out, based on well tests, geophysical survey results and other relevant information. These simulations are performed repeatedly, varying the various unknown parameters to maximize agreement between measurements and computed results. And then a nearly steady natural-state representation is obtained. Reservoir responses to production with time are carried out to estimate an optimum reservoir development plan. NEDO has developed the simulators. Kirishima and Sumikawa geothermal fields have been selected for study, and NEDO has been engaged in well drilling, a various geological and geophysical surveys jointly with private enterprises. NEDO has drilled deep observation wells from 1500 m to 1700 m in depth, and measured the reservoir pressure including pressure interference experiments. In the Kirishima field, the average total recharge rate was reaching 670 tons per hour in 1987. This increase in discharge rate resulted in a significant pressure decrease in observation well amounting to 0.2 MPa. A deep high-permeability zone at Sumikawa is confined by flow barriers with a north-south orientation. Reservoir simulations were carried out by NEDO's model. 2 tabs., 7 figs.

7299 (GRSJ–8901, pp. 422-425) **Dilution and boiling in the Wairakei field due to exploitation 1959-1982.** Brown, K.L.; Henley, R.W.; Glover, R.B.; Mroczek, E.K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Chemical changes in the Wairakei geothermal field, New Zealand were examined, which had occurred as a consequence of the massive withdrawal of hot water for power generation over a 30 year period. Deep hot water features were estimated from early data, and after chemical changes induced by local boiling and vapor loss were filtered out, the principal changes and their relative rates in the production area were assessed by the data for the succeeding 30 year period. To assess the effects of exploitation, the chemical compositions and temperatures of the primary diluting fluid and principal upflow lying to the west of the present production field were estimated. The correction method of production well data by an enthalpy/chloride mixing diagram was given, and the local distributions of corrected chloride concentrations were illustrated for the years prior to 1961 and for 1981-1982. The changes with time of chloride concentrations in the western and eastern borefield were illustrated to discuss the cause of their lowering trends, and moreover, a reservoir size was estimated from a chloride mass balance. 8 refs., 6 figs., 2 tabs.

7300 (GRSJ–8901, pp. 441-444) **Thermal regime and ground-water movement in the Pripyat trough.** Parkhomov. M.D. (Inst. of Geochemical and Geophysicals, Minsk (USSR)); Zui, V.I. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The space-time structure of the Pripyat Trough geothermal field and groundwater basin corresponding to the upper part of a platform cover section were examined. Temperature was measured in 68 boreholes up to more than 2000m in depth, and used to develop the stochastic model of the geothermal field together with thermophysical properties of rocks. Three-dimensional model of heat flow density and its divergence distribution was thus developed based on the stochastic model. The model enabled to study the heat flow density distribution in the platform cover section, to explain deep seated heat flow anomaly, and to analyze spatial peculiarities of the heat flow distribution over a range from land surface to 2000m underground. As the result of analysis for the Pripyat Trough geothermal structure composed of an active water exchange zone, slow water exchange zone, stagnant hydrodynamic regime zone, salt deposits and crystalline basement, there was the predominant influence of convective heat exchange in the upper part of the platform cover section, and it was made clear that filtrating water completely smoothed the heat flow anomaly in the active water exchange zone. 8 refs., 1 fig.

7301 (GRSJ–8901, pp. 445) **New model of Black Sea crust and upper mantle thermal regime and its correspondence to geophysical data.** Suetnova, E. (Inst. Physical of the Earth, Moscow (USSR)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Heat flow from the mantle and sedimentation produces thermal anomalies within Black Sea crust and lithosphere. A one dimension conductive heating model is developed to simulate the thermal effect of sedimentation. The variable rate of sedimentation is considered according to geophysical data. The single uniformly valid solution of thermal conductivity aquation is found in the case of sedimentation under unstationary lower boundary condition. Application of the model to data from Black Sea basin suggest that heat flow from mantle are low. Thermal regime obtained for the depth are discussed in terms of geophysical/regional isostatic anomaly, P-wave velocity putterns/data for the region.

7302 (GRSJ–8901, pp. 446) **Quaternary volcanism as the heat source for some geothermal fields in Kyushu, Japan.** Hayashi, M. (Kyushu Univ., Fukuoka (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The relation between volcanic and geothermal activities in Kyushu will be discussed in terms of the activity index and radiometric ages of volcanic rocks distributed in and close to geothermal fields. The activity index is defined as the ratio of temperature measured in a well to the boiling temperature, and ranges from 0 to 100. There run two volcanic belts in Kyushu: the Daisen volcanic belt trends from ENE to WSW including Yufu-Tsurumi Volcano, Kuju Volcano and Unzen Volcano, and the Kirishima volcanic belt trends from NNE to SSW including Aso Volcano, Kirishima Volcano, Sakurajma Volcano and Ikeda Volcano. Hornblende andesites characterize the former and pyroxene andesites the latter. In geothermal areas where hornblende andesites are abundant, very active fields are located in the vicinity of a volcano younger than 0.20 Ma. On the other hand, in geothermal areas covered with pyroxene andesites, the associated volcano is much younger. The above facts suggest that a volcano consisting of hornblende andesite tends to cool down more slowly than one consisting of pyroxene andesite. In addition, larger volcanoes tend to have a longer life as heat sources. As mentioned above, the geothermal activity of a reservoir is closely related to the age of associated volcanoes and also to their chemical composition and volume. Accordingly, the research on volcanoes should be the first required step for geological exploration of geothermal resources. 2 figs.

7303 (GRSJ–8901, pp. 447-450) **Hydrogen and oxygen isotopic rations of thermal water in Oyasu-Uenotai area, Akita, Japan.** Matsubaya, O. (Akita Univ. (Japan)); Uchida, H; Iwata, S. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Hydrogen and oxygen isotopic ratios of thermal water collected from exploratory wells in the Oyasu-Uenotai area were measured, and the origin of the thermal water was estimated in comparison with the isotopic features of meteoric water and natural thermal water in the vicinity. Thermal water data were collected at a few days interval after the beginning of ejection in five wells. Because of the relation between ΔD and $\Delta^{18}O$ of thermal water in all wells, these thermal waters were supposed to be of meteoric origin, but not be directly connected with the geothermal system of organic origin. Since ΔD of the thermal waters were lower by 5-10 mil% than that of meteoric water, if the thermal waters were derived from original thermal water with the same ΔD as meteoric water, the lowering of ΔD could be caused by underground boiling. Since the differences of the isotopic ratios between the wells were clearly larger than fluctuation within each well, it was suggested that there was no horizontal connection among the wells, and the thermal waters might come up separately through isolated vertical fissures reaching a deeper part. 8 refs., 3 figs., 1 tab.

7304 (GRSJ–8901, pp. 452) **Geothermic fields of faults.** Sardarov, S.S. (Inst. of Geothermic Problems, Makhachkala (USSR)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In terms of heat and mass transfer, a fault can be fully modeled by a vertically placed seam system. It is intuitively expected that heat flows over faults ought to increase, however, a minute geothermic survey shows it is no general phenomenon. Measurements of heat flow in especially bored wells make clear that a geothermal field along a fault has a mosaic structure composed of high and low heat flow zones arranged alternately. Approximate equation of temperature disturbance is derived from the law of mass energy and impulse conservation in a porous medium, and as the Rayleigh number of the equation is greater than its critical number, convection develops giving rise to a geothermal field with a variable structure, and the mosaic geothermal field is thus formed. As the results of the investigation on the geothermal faults in USSR, heat flows are measured in drill holes 50-100m underground, and a geothermal field is a regular alternation of zones with sharply high and low heat flow values.

7305 (GRSJ–8901, pp. 583-585) **Development of simulator for hydrothermal system and its application to a real field.** Yuhara, K. (Kyushu Univ., Fukuoka (Japan)); Fujimitsu, Y. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–; International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

A three-dimensional simulator composed of three computer codes for hydrothermal system has been developed. Those codes are for expression of steady-state convection system of thermal water, transient behavior of tracers cast into a geothermal reservoir with a know steady flow of thermal water and transient behavior of thermal water and behavior of tracers in the transient flow. In the simulator, we assume that (1) the liquid phase incompressible thermal water is flowing through a porous medium following Darcy's law, (2) there is temperature difference between the thermal water and the surrounding porous medium, (3) the variations of water density can be described by the Boussinesq approximation and (4) the variation of the kinematic viscosity can be approximated by the equation shown by Wooding. Takenoyu and Sugawara area, across the border of Kumamoto and Oita prefecture, central Kyushu, was chosen as a field of the numerical modeling, where is a developing field of geothermal resources and many kinds of investigations have been carried out. The geological, geophysical and well logging data are compiled and the valued of physical properties are assigned to each block. These values and boundary conditions are modified to construct a natural state model of this area. 6 refs., 3 figs.

7306 (GRSJ–8901, pp. 526-529) **Fluid inclusion evidence for recent temperature rising at Fenton Hill Hot Dry Rock test site west of the Valles Caldera, New mexico, U.S.A.** Sasada, M. (Geological Survey of Japan, Tsukuba). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

To determine the recent thermal history of the Henton Hill Hot Dry Rock test site, the homogenization temperature and final melting point of ice of fluid inclusions were measured microthermometrically using the core samples from 1876m and 2624m in GT-2 drill hole. As a result, the fluid inclusions in the calcite veins and in quartz of the Precambrian crystalline rocks from the GT-2 indicated the thermal history such as heating up to the thermal maximum, cooling calcite veining and heating again to the present temperature. More particularly , the reequilibration of secondary inclusions in the Precambrian crystalline rocks occurred at the thermal gradient maximum of 70°C/km, and the calcite veins formed at the temperature of 10-15°C lower than the minimum reequilibration temperature. The lowest temperature reached after the thermal maximum was 152°C or lower at 2624m, which was at least 26°C lower than the present borehole temperature of 178°C. After that, the temperature increased again to the present thermal gradient. 18 refs., 4 figs.

7307 (GRSJ–8901, pp. 532-534) **Actual problems of developing the utilization of low-temperature, high-enthalpy geothermal energy.** Kontra, J. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In many of the territory of Hungary, geothermal energy is won from Upper Pannonian sandstone layers, transferred by thermal water energizing at a temperature below 100°C. Decrease of the water resources and of the bed pressure induces users to utilize thermal waters at lower temperature levels. Geothermicians have developed peculiar well design methods: partially heat insulated, or double-function wells are yielding thermal water at an improved economy in several Hungarian cities such as Szentes, Mako, Mosonmagyarovar. Separating heat and mass flow of geothermal energy up-to-date, automatically controlled utilization implements have come about. The recently designed complex geothermal thermal-and-mineral water systems in Mosonmagyarovar can be operated at a temperature level below the nominal 90/70°C usual in heating buildings, without accessory heat production or other energy carriers. Important problems arise from the lack of a solution for exploiting high-enthalpy geothermal energy made to emerge in recent years. Utilization of the steam of a salinity and a pressure differing from those usual in this country, and also at a higher temperature is actually subject to theoretical considerations. 3 figs.

7308 (GRSJ–8901, pp. 518-521) **Volcanic history at the Matsukawa- Kakkonda area, Northeast Japan.** Suto, S. (Geological Survey of Japan, Tsukuba); itaya, T.; Mukoyama, S. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The tectonic of the Sengan geothermal area was outlined, and the results of a paleomagnetic analysis and K-Ar dating were reported. Samples were collected at 23 sites in the Matsukawa-Kakkonda area, and the magnetization intensities and directions of the samples were measured and examined with K-Ar dating data. As a result, young volcanoes in the Sengan geothermal area were divided into the early stage and later stage ones, and while Mitsuishiyama, Nyutozan and Kurikigahara volcanoes belonged to the later stage ones, the rest to the early stage. The volume of effusive rocks of Mitsuishiyama and Kurikigahara volcanoes was considerably smaller than that of Iwate volcano or Matsukawa andesite. There were no mutual relations between the sites of geothermal power plants and the eruption ages of the nearest volcanoes in the Sengan area. The heat source in the Sengan area was supposed to be the complex of heat from various magma reservoirs effused into volcanic rocks intermittently including the Tamagawa welded tuffs. 9 refs., 5 figs., 3 tabs.

7309 (GRSJ–8901, pp. 522-525) **Geological analysis of the Kakkonada geothermal reservoir.** Doi, N. (Japan Metals and Chemical Co., Ltd., Iwate); Muramatsu, Y.; Chiba, Y.; Tateno, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

As a part to develop geothermal reservoirs successfully, the permeable fracture distributions and their geneses in the Kakkonda geothermal field were discussed in connection with a geological subsidence, folding, magma intrusion. Seven production and reinjection wells drilled for a geothermal power plant revealed the geological conditions such as fractures, dykes, hornfels and temperature distributions in deeper depth. There were three types of permeable fractures in the genesis in the Kakkonda field. The first was the intensely fractured zone of 1000-1600m in depth in the NW-Se direction supposed to be formed by a subsidence in the early to middle Miocene age, the second was the folding fractures supposed to be related to the first type in the genesis, and the final was the magma intrusion fractures supposed to be formed by magma fracturing to wall rocks and flexural flows in viscous dacite magma, as was suggested from circulation losses at the margin and in the dyke. 5 refs., 6 figs.

7310 (GRSJ–8901, pp. 533-536) **Stereography of geological and geothermal structure.** Shoji, T. (Univ. of Tokyo (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

A computer system for the stereography has been developed and applied to the Nishiyama geothermal field. The Nishiyama geothermal field is located 30 km west of Lake Inawashiro, Fukushima. The geology consists of Tertiary and Quaternary volcanic rocks. The basement rock is considered to be Pre-tertiary granitoid. The sedimentary rocks including lava and pyroclastics are divided into five formations. The Ogino formation consists of mainly of rhyolitic pyroclastic rocks, and partially of andesitic to basaltic pyroclastics. Urushikubo formation consists of mudstone, tuffaceous sandstone,

basaltic pyroclastics and rhyolitic lava. The Sunagohara formation of a lake deposit is composed of sandstone, mudstone, siltstone and conglomerate. The gravity data suggests that the basement is shallow in the southeastern area, and deep in the northwestern one. Roughly speaking, the formation shows the same trend. However, the structure does not always coincide with that of the basement. The formations are folded, and form locally many domes, basins, anticlines, and synclines. The fracture system consists of two groups. The one strikes northwestwards, and the other northeastwards. The geothermal structure was analyzed using the data obtained from 32 drill holes. The high temperature zone is localized along two geologic faults,and Nishiyama hot spring is located in these districts. Some examples of stereoimage of geothermal structures were shown. 2 refs., 7 figs.

7311 (GRSJ–8901, pp. 557-560) **Interpretation of a pressure interference test of the Sumikawa geothermal field.** Maki, H. (New Energy Development Organization, Tokyo (Japan)); Pritchett, J.W.; Garg, S.K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

A pressure interference tests of the Sumikawa geothermal field were interpreted. Pressure interference testing is a fundamental tool for establishing reservoir connectivity and for computing interwell properties. Well S-4 was discharged and pressure measurements of four observation wells including KY-1 were made. A clear response was immediately recorded in Well KY-1, when Well S-4 started to discharge. Well-test interpretation technique was based on the single-phase, radial flow model. Well KY-1 is located directly north of 1120m apart from Well S-4. A channel model with northern and southern boundaries, which were running east-west, was applied to the analysis of geothermal structures. This model is characterized by four free parameters; the north-south permeability k_y, the cross-section A, the location of the southern constant-pressure boundary Δy_s and the location of the northern impermeable boundary Δy_n. The optimum fit was obtained with the following parameter values: K_y = 195 millidarcys, A = 0.51 km^2, Δy_s = 9.86 km, Δy_n = 2.56 km. If this geometric interpretation is valid, the implication is that another north-south vertical barrier is present 0.2 - 0.3 km east of Well S-4. 2 refs., 4 figs.

7312 (GRSJ–8901, pp. 565-566) **Monitoring of geothermal activities by infrared measurement at the Komatsu-Jigoku fumarolic area near the Hatchobaru geothermal power station.** Yuhara, K. (Kyushu Univ., Fukuoka (Japan)); Ehara, S.; Kuboguchi, M.; Fujimitsu, Y. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Monitoring results by infrared measurements adopted in the Komatsu-Jigoku area since 1976 were reported comparing with results by a direct method. As anomalous surface temperature measured by the infrared method was compared with ground temperature 1m underground measured by the direct method and the locations of hot springs and fumaroles, the anomalous area well agreed with the area of shallow hot ground. Since heat discharges measured by the infrared method (heat balance method) included only part of heat transferred by the fumaroles, they were smaller than those estimated by the direct method, however, both heat discharges were relatively constant through the overall measurement period. It hence meant that the geothermal activity of the Komatsu-Jigoku was the same before and after the exploitation of the Hatchobaru geothermal field. Although the infrared method was impossible to catch all the natural heat discharges, it required only two persons for one hour, while the direct method required six to ten persons for two or three days. It was, then, greatly convenient, useful method for the monitoring of geothermal activities. 6 refs., 2 figs.

7313 (GRSJ–8901, pp. 567-568) **Geophysical exploration at Takigami geothermal field in Oita Prefecture, Japan.** Aoki, M. (Idemitsu Geothermal Co., Ltd., Tokyo (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Remote sensing study, gravity and magneto-telluric (MT) surveys in Takigami geothermal field were carried out. A great number of E-W lineaments are easily recognized with LANDSAT and so on. These E-W lineaments might be distinguished into two groups. One group might be considered to be made simply related to N-S tensional stress, the other has circular feature enclosing mountainous body. The center part of the volcano seems to be depressed relatively. These lineaments are thought to be associated with the volcanic activity which created these volcanos, in addition to the regional tensional stress. The gravitational slope is steep and inclines to the west (-35m gal minimum), the easternmost part is almost on the gravitational high. Takigami area is positioned on the gravitational slope, probably related to the large-scale tectonic depression. There are many geothermal active manifestations. The correlation between MT data and real logging data was excellent beyond expectation. In Takigami area, surface layer is resistive and shows 30-500Ω-m. Intermediate layer is extremely conductive one with 1-10Ω-m. Bottom layer is relatively resistive and is within 30-500Ω-m. Intermediate layer is shallow and thin in the eastern part. On the other hand, this layer is deep and thick in the western part. This shape of structure is a common feature with gravitational structure. According to the X-ray diffraction study of hydrothermal alteration, surface layer is unaltered, but intermediate and bottom layer suffer hydrothermal alteration.

7314 (GRSJ–8901, pp. 570-571) **Relation between the geotemperature distribution and the geotectonics in China.** Jin, X (Changchun College of Geology, Jilin (China)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Geotemperature distribution in China is discussed to be controlled by a geostructural framework and its position in the global tectonics. High temperature geothermal regions almost correspond with modern faulting and volcanic activities, and recent magmatic movements located on the edges of the lithospheric plates. Geothermal anomalous areas in China are one part of the global geothermal zones, and are affected by the motions of the Eurasian, Indian, Pacific and Philippine sea plate. In particular, in Asian continent during Cenozoic, the collision between the Indian and Eurasian plate has resulted in the geothermal anomalies in South-Western China, and that between the Eurasian and Pacific plate has resulted in that in Eastern and South-Eastern China. By the relation between a geothermal anomaly and fault system, the anomalous geothermal zones can be separated into following three groups: (1) the high temperature zones including Tibet-Yunnan and Taiwan geothermal zone, (2) the intermediate and low temperature zones including South-eastern coast and Chinling geothermal zone and others, (3) the high heat flow zones including South sea region and others. 2 figs.

7315 (GRSJ–8901, pp. 576-578) **Investigation of a reinjection geothermal water flow by the activable tracer method and the application of a tracer model.** Yuhara, K. (Kyushu Univ., Fukuoka (Japan)); Huang, H.; Matsuoka, N. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The influence of the production and reinjection of geothermal fluid to natural hot springs were investigated by means of Dy-DTPA tracer technique. As a preliminary investigation, 1kg Dy-DTPA was injected from a reinjection well, and it was sampled at surrounding four production wells and five hot springs once a week for about a month. The breakthrough of the tracer was observed almost at

every sampling point. The geothermal reservoir here seems well interconnected. The flow of the injected water from the reinjection well is somewhat controlled by the general flow in the reservoir, which coincides with the topography. The discharge of the production wells made the moving of the reinjection water predominantly faster. The reappearing concentration change with time can be shown as mathematical function. Parameter used are as follows: D(l) is the dispersion coefficient of the tracer; E(l), the effective initial concentration; r(l), the distance vector from the reinjection well; V(l), the average velocity of the groundwater flow. l means the dimension of the model to be used. These theoretical results were applied to the above mentioned tracer test. When the breakthrough curve is higher, it might be interpreted that those tracer formal stopped at dead-end are washed out later, or the path for the tracer to the sampling site are several, or the volume of the reservoir is limited. When the breakthrough curve is lower, it might be for the adsorption or the decomposition of the tracer. 1 fig.

7316 (GRSJ–8901, pp. 602-607) **Structural evaluation of geothermal fields in Japan.** Acharya, H. (Stone and Webster Engineering Corp., Boston, MA (USA)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

To identify the influence of plate underthrusting on the locations of hot springs over 90°C in temperature, and on the structural evolution of both hot springs and geothermal fields, the locations of hot springs in Japan were surveyed along with such characteristics as Na/K ratio, flow rate, and rate of volcanic activity. Hot springs in Japan were, as a result, situated in clusters in the volcanic areas along the extension of transverse zones indicating discontinuities in plate underthrusting. Geothermal fields exploited to date were located in the vicinity of these clusters of hot springs, and heat flow measured in many of these zones was higher than average for volcanic areas. Since the distribution of hot springs suggests that the hot springs in transverse zones may be the most favorable indication of higher temperatures at shallow depths in the crust, such zones with higher-than-average crustal temperatures may be favorable for the development of productive geothermal fields if local geological and hydrological conditions permit. 17 refs., 3 figs.

7317 (GRSJ–8901, pp. 616-617) **Compilation of the heat flow data in and around Japanese island with a personal computer.** Nagao, T. (Kanazawa Univ., Ishikawa (Japan)); Yamano, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The Japanese Islands and the surrounding area are one of the best investigated subduction zones. The most notable features of heat flow distributions in this area are the existence of a low heat flow zone in the Pacific Ocean Side of Northeast Japan Island Arc and a high heat flow zone in the Japan Sea side. At this stage, the number of data reached over 1600. The heat flow data in the South-East Asia compiled, and the total number of data is about 900. Our compilation includes heat flow value, latitude, longitude, geothermal gradient, thermal conductivity, altitude and/or water depth, number of data is used to determine both geothermal gradient and thermal conductivity, measurement range and reference code. Each heat flow data compiled by personal computer. The compiled heat flow data can provide both on a magnetic tape and a floppy disk. The distributions of heat flow data in a target area and heat flow cross section of the target area can be obtained by personal computer. This data base management can be applicable any part of the world. 4 refs., 2 figs.

7318 (GRSJ–8901, pp. 618-621) **Redistribution of terrestrial heat flow by deep circulating meteoric waters recharging low temperature geothermal systems.** Ehara, S. (Kyushu Univ., Fukuoka (Japan)); Hochstein, M.P.; O'sullivan, M.J. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In this study the results of numerical modeling of two fracture zone systems are described: the Waiwera system in New Zealand and the Fuzhou system in China. The study allows a quantitative assessment of the redistribution of terrestrial heat for both systems. Simulation of the complete secular convection of two low temperature fracture zone systems has shown that, even for basement rocks of low permeability (order of 10^{-16} m^2), deep penetration of meteoric waters is required to transfer heat from the upper 5 km of the crust towards the fracture zones. initially this causes a significant cooling of upper crustal rocks in the recharge area; when steady state convection is reached, some heat supplied by the undisturbed terrestrial heat flow is transferred in to the reservoir. In the case of the Waiwera system, the crustal heat flow is reduced by about 20 mW/m^2 within a radius of about 4 km; at Fuzhou the heat flow is probably reduced by about 50 mW/m^2 for distances greater than 7 km away from the fracture reservoir. The setting up time for each circulation pattern until steady state convection occurs is large, and was found to be about $2 * 10^6$ yr for both systems. Low temperature systems of the Waiwera/Fuzhou type are therefore rather old systems. 17 refs., 4 figs.

7319 **Some effects of non-condensible gas in geothermal reservoirs with steam-water counterflow.** McKibbin, R. (Auckland Univ. (New Zealand). Geothermal Inst.); Pruess, K. *Geothermics (USA),* 18(3): 367-375 (1989).

A mathematical model is developed for one-dimensional fluid and heat flow in two-phase geothermal reservoirs containing non-condensible gas (CO_2). Vertical profiles of temperature, pressures and phase saturations in steady-state conditions are obtained by numerically integrating the coupled ordinary differential equations describing conservation of water, CO_2 and energy. Solutions, including binary diffusion effects in the gas phase, are generated for cases with net mass throughflow as well as for balanced liquid-vapor counterflow. Calculated examples illustrate some fundamental characteristics of two-phase heat transmission systems with non-condensible gas.

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Refer also to citation(s) 7224, 7233, 7235, 7245, 7247, 7256, 7257, 7261, 7272, 7277, 7278, 7280, 7282, 7289, 7290, 7293, 7294, 7297, 7309, 7310, 7312, 7314, 7315, 8441

7320 (GRSJ–8901, pp. 43) **Homogenization temperatures of fluid inclusions versus borehole temperatures.** Sasada, M. (Geological Survey of Japan, Tsukuba). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The author summarized the relationships of homogenization temperatures (Th), trapping temperature (Tt) of fluid inclusions and the borehole temperature by indicating several recent studies. The one example is that Th of fluid inclusions trapped at the latest thermal event may indicate the present temperatures of geothermal reservoir. The next is that the significant temperature difference between Th and borehole temperature can be explained by decrease of temperature after the full trapping of fluid inclusion in hydrothermal minerals or transition from hot water dominated system to vapor dominated one. The another is that the present temperature in geothermal reservoirs may be higher than previous Th of fluid inclusions under high geothermal activity. The author concluded based on the above reviews that the recovery of Th of fluid inclusion and final temperature can play an important role to delineate the thermal history of underground geologic formations in geothermal fields. 8 refs.

7321 (GRSJ–8901, pp. 55-58) **Geochemical monitoring system of production well in Hatchobaru geothermal area.** Koga, A. (Kyushu Univ., Fukuoka (Japan)); Umehara, S.; Hirowatari, K.

Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This paper summarizes geochemical monitoring of thermal fluid with time, reinjection effect by the lots of geochemical data of Hatchoubaru geothermal area reported during the period 1963-1988. In advance, the author provides the principle of geochemical monitoring system by chloride behavior, Na/Ca ratio and gas composition which are explained with relations to dilution with other water, temperature of fluid and oxidation state, respectively. The author characterized the geothermal fluid from the five geochemical points, namely, (1) Changes in Cl concentrations and enthalpies with at Hatchoubaru geothermal area, (2) Changes of $Cl/(Cl+SO_4+HCO_3)$ ratios with time, (3) Changes of Na/Ca ratios with time, (4) increase of chloride concentration by reinjection and (5) Changes of water/vapor ratios and N_2 gas contents with time. The individual change geochemical variance are interpreted with reinjection effect or cold water mixing. 14 figs.

7322 (GRSJ–8901, pp. 69-70) **Temperature gradient map of the Hakkoda geothermal area.** Okubo, Y. (Geological Survey of Japan, Tsukuba); Muraoka, H. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This report shows the temperature gradient map, drawn by the authors on the basis of temperature log data from ninety nine boreholes in the Hakkoda geothermal area. The following facts are noted. Volcanoes and hot springs locate in high temperature gradient regions. High anion index zones roughly correspond to high temperature gradient ones. One of high temperature gradient zones occurs in the changing area of Bouguer anomaly. 3 refs., 3 figs.

7323 (GRSJ–8901, pp. 71-74) **Ground electric current at geothermal area.** Ito, Y, (Kanto Gakuin Univ., Yokohama (Japan)); Shibata, A.; Kirihara, H.; Nagumo, M.; Tanaka, Y. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

There is reported the observation by the authors on the geothermal electric current at the Goshogake geothermal area, Akita prefecture. The measurement was carried out with both self potential method and spectrum one. The obtained results of three quantities at each observation point are shown on separate maps; gradient vectors of self potential, predominant frequencies of spectra and orbits of predominant frequency of geothermal electric noise. 7 refs., 6 figs.

7324 (GRSJ–8901, pp. 75-77) **Self-potential changes induced by geothermal fluid production.** Kikuchi, T. (Geological Survey of Japan, Tsukuba); Sugihara, M.; Ishido, T. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This is the report of an attempt to investigate the influence of fluid production at geothermal reservoirs by self-potential (SP) method. The noticeable surface SP change distribution was observed by the authors at the Nigorikawa caldera, Hokkaido, when the geothermal power plant built there started its operation. Referring to the recent works on geoelectricity, the authors assumed this SP change had been generated by the production of geothermal fluid. To verify this assumption, quantitative calculations of the induced SP change for a simple model was carried out, on the basis of the following two factors: first, pressure change induced by production of fluid; second, discontinuity of streaming potential coefficients in the neighborhood of geothermal reservoir. The calculated SP change distribution for the model roughly reproduced the observed one. The SP anomaly observed at the Onikobe caldera, Miyagi prefecture, is briefly noted as one more example. 5 refs., 3 figs.

7325 (GRSJ–8901, pp. 78-81) **Interpretation of Schlumberger sounding data in geothermal areas.** Wang, Jia-zhao (Chengdu College of Geology, Sichuan (China)); Ushijima, Keisuke. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This report offers the interpretation of vertical electric sounding (VES) data obtained in the field near the Hachobaru geothermal power station, Oita prefecture. VES curves derived from a series of resistivity sounding measurements are interpreted by means of the resistivity inversion method. It is confirmed that the section of resistivity layer at each station consists of the following three formations: first, the surface zone with high resistivity of 500-1300 ohm-m; second, the intermediate layer with low resistivity of 2.1-6.3 ohm-m; third, the electrical basement with high resistivity of 180-1200 ohm-m. Laterally comparing these resistivity layer sections with the drilling data from production wells, the geoelectrical structure model is composed for the geothermal reservoir of this field, which can be effectively used to develop another geothermal resources of the same field. 2 refs., 5 figs.

7326 (GRSJ–8901, pp. 39-42) **Investigations on hydrothermal activities using fluid inclusion geothermometry in the Otake and Hatchobaru geothermal fields.** Takagi, H. (West Japan Engineering Consultants, Inc., Fukuoka); Fujino, T.; Kurokawa, K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This paper describes the fluid inclusions study in hydrothermal minerals such as quartz, anhydrite and calcite from wells in the Otake and Hachoubaru geothermal fields. It is clarified that the homogenization temperature of the well from Hachoubaru are relatively wide at shallower depths levels and are relatively narrow at deeper depths. The wide range of homogenization temperature at shallower depths is ascribed to the mixing process between the cold water at shallower depth and the hot water from deep level. It is also clarified that the homogenization temperature of the other well in reinjected zone from Hachoubaru show a bimodal distribution. The minimum value of the low temperature peak agree with the present temperature, whereas the value of the higher temperature peak appears to be equal to the original reservoir temperature. In the Otake geothermal field, it was clarified from fluid inclusions data that the geothermal fluid coming from the south formed a reservoir of 200-220°C at the level of 500 m below surface. 3 refs., 7 figs., 1 tab.

7327 (GRSJ–8901, pp. 82-85) **Some field test results of high accuracy MT system.** Takasugi, S. (Geothermal Energy Research and Development Co., Ltd., Tokyo (Japan)); Kawakami, N.; Miura, Y.; Muramatsu, S. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The real time, 4-point triple-reference processing magnetotelluric (MT) method has been developed by the authors for the purpose of improving the accuracy of MT measurement in the mountainous and noisy fields of Japan. Its field test proved some desired effects as follows: first, triple-reference processing can be expected to remove noise efficiently, especially the long-distance remote-reference MT method is very effective to eject regional noise; second, frequency band for data processing is expanded to far wider range than that of the conventional MT system, making it possible to analysis from shallower to greater depth than even before; third, carrying out measurement with shorter spacing of observation points, more detailed resistivity section can be derived than that with ordinary spacing of points. 6 figs.

7328 (GRSJ–8901, pp. 86-99) **Case study of a high accuracy MT survey at Sugawara, Kyushu.** Kawakami, N. (Geothermal Energy Research and Development Co., Ltd., Tokyo (Japan)); Takasugi, S.; Miura, Y.; Muramatsu, S. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This paper reports the results of analysis of the data obtained by the survey in the Sugawara field, carried out for the purpose of testing the operative characteristics of the real time 4-point triple-reference processing MT system. The results are compared with resistivity logging at wells in the same field covering an area of 15km^2. From the ground surface downward, resistivity generally changes from high values (> 20 Ω*m) to low ones (< 20Ω*m) and then to high ones (> 20Ω*m). However, even at the greater depth of about 1000 m and more from the surface, lateral change of resistivity is somewhat complicated, the area of high resistivity, 100Ω*m or more, and the area of low resistivity, 20Ω*m or less, occurring side by side with discontinuous boundary between them. Geologic interpretation is presented which correlates the resistivity distribution with rock formations and geologic structure of the area. 4 figs.

7329 (GRSJ–8901, pp. 90-92) **Three dimensional modeling of geoelectrical structure in Hirayu Hot Spring.** Mogi, T. (Kyushu Univ., Fukuoka (Japan)); Kajiwara, T. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This is the report on the effects of applying three dimensional modeling technique to the investigation of resistivity structure of the Hirayu Hot Spring area, Japan. Having ascertained that two dimensional modeling leads to inevitable error in case of large lateral change of resistivity, the authors tried to apply more elaborate modeling. Iterative calculation by means of finite element method was carried out, based on 20-noded isoparametric hexahedral element and of second order shape function. In all, the model required 10,333 modes and 2,184 elements for the area of about 0.5 km^2. Compared with two dimensional modeling, it is ascertained, there dimensional modeling brings about several remarkable effects for such a complicated resistivity structure as the one of this area. 1 ref., 5 figs.

7330 (GRSJ–8901, pp. 93-96) **Geothermal exploration by the earthing method.** Ushijima, Keisuke (Kyushu Univ., Fukuoka (Japan)); Tagomori, Koichi; Matsumoto, Tadashi. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This paper reports the result of processing the data of the method of ground charging measurements in Hatchobaru geothermal area. The actual voltage values measured at each station are transformed into the apparent resistivity and compared with the theoretical values in order to get residual anomalies, which are derived from DC resistivity, magnetotellurics or well logging through numerical modeling. In this field the method of ground charging survey shows sharply contoured residual anomalies, because of high contrast in resistivities among surrounding rocks, hydrothermally altered zones and geothermal fluids, making it possible to determine by this method the distribution of low resistivity zones and the lateral change of geothermal reservoirs. Residual potential anomalies obtained by similar procedure as the above are also effectively used. 2 refs., 5 figs.

7331 (GRSJ–8901, pp. 117-118) **Seismic exploration in the Fushime geothermal field, Kagoshima prefecture.** Yoshimura, Y. (Japan Petroleum Exploration Co., Ltd., Tokyo); Nakagome, O.; Okazaki, K.; Ikawa, T.; Kuroda, T. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The reflection seismic survey is effective to define the subsurface structure for petroleum exploration. However, good quality seismic reflections can not be obtained through the geothermal exploration in the non-sedimentary field, because of difficult working in the topographically rough area, non-layered and complex geological structure, and low transmission of seismic energy due to the volcanic flow. In spite of those difficulties, the reflection seismic survey gives expectation to detect the indication of faults and fracture zones, as conduits for the geothermal fluid. After examining the data obtained from the previous reflection seismic survey, by the conventional technique for petroleum exploration in Fushime geothermal field in 1978, an experimental reflection survey was newly made in the same field in 1986, in order to find the suitable field parameters, which were compared with the previous ones and briefed in this report. The specified parameters are energy source, SP (VP) interval, geophone frequency, geophone group interval, number of channels, sampling rate and number of folds. The newly processed results showed a better resolution than the previous data and are useful to delineate the geothermal structure in the future. 2 figs., 1 tab.

7332 (GRSJ–8901, pp. 104) **Micro-earthquake activities and crustal structure in the geothermal field.** Kubotera, A. (Kyoto Univ. (Japan)); Omote, S.; Mitsunami, T. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The micro-earthquake activity and crustal structure in Hohi geothermal area, around the Kuju volcanic mountains, Kyushu Island, Japan, were investigated. The micro-earthquakes, proper to that area, are distributed in a belt zone along fault lines, clearly developed in the geothermal area. In that belt zone, swarm type micro-earthquake activity is observed, with a short duration of swarm occurrence and shifting nature of swarm activity-concentrating location. Artificial explosions were made, for the refraction seismic survey purpose, on 11 sites, where seismic waves were recorded at six short period seismograph stations, forming a permanent seismic network. From the time term analysis, P wave velocity of 5.8km/sec was obtained in the basement layer, while time terms (delay times) ranged between 0.07 through 0.73sec. The time terms are small where granitic or metamorphic rock crops out, while large where a low gravity anomaly exists. In Kuju caldera, the time term pattern is convertible to the thickness pattern of upper layer, overlying the basement, estimated about 3km in depth, under assumption that the upper layer is constant in P wave velocity, estimated 3.3km/sec by the travel time-distance curves.

7333 (GRSJ–8901, pp. 273) **Geothermal development in Indonesia.** Radja, V.T. (State Electricity Corporation, Jakarta (Indonesia)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The volcanic belt in Indonesia, rich in geothermal energy source, is associated with a 7000km long plate boundary. The number of volcanic center in Indonesia is 177, of which 88 bear evidences of fumarol and solfatara activities. The geothermal potential of the country is estimated to be about 10000 MWe. Geothermal investigations having started in 1918, a relatively long period of 1928 through 1964 elapsed for starting the commercial utilization of geothermal resources in Indonesia. Geothermal exploration was reactivated in 1964 with many domestic and foreign organizations involved therein. Indonesian organizations were VSI, PLN, LTB and PERTAMINA while foreign organizations were UNESCO, Tokyo University, USAID, New Zealand Government and JICA with their contribution made to the geothermal development for 20 years, of which the largest came from New Zealand Government, assisting Indonesia with constructing a 30MW power plant and steam field development in West Java. In 1981, PERTAMINA was granted the

authority to undertake the exploration and exploitation of all geothermal energy source in Indonesia.

7334 (GRSJ–8901, pp. 298-301) **Compilation of heat flow in East Asia.** Matsubayashi, O. (Geological Survey of Japan, Tsukuba); Nagao, T.; Yamano, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Heat flow data file of the East Asia is presented, which stores large amounts of heat flow data, and enables a computer to compile the data. The data of approximate 1000 stations collected from published reports with unpublished data of some heat flow stations are at present stored in the international format file. Marine heat flow data were extracted from the data compiled by the International Heat Flow Commission in 1983, and on-land data together with offshore deep well data since late 1970s were collected in cooperation with many countries except on-land data of USSR. Based on the illustrated southern half of the heat flow map compiled by a computer, the present conditions of heat flow surveys are outlined in terms of continental parts such as China and Thailand, inlands of East Asian Islands except the Japanese Islands, marginal seas such as the South China Sea, and continental shelves. A heat flow variation chart along SW-NE transect passing through the Central Sumatra, Sunda Shelf and South China Sea is illustrated as an example of heat flow charts along transects to visualize heat flow variation. 23 refs., 2 figs.

7335 (GRSJ–8901, pp. 240-243) **Influence of borehole capacity on pressure buildup during cold-water injection.** Nakao, S. (Geological Survey of Japan, Tsukuba); Yano, Y.; Kikuchi, T.; Ishido, T. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Pressure-transient testing of wells is the standard procedure for estimating the transmissivity structure of geothermal reservoirs. While long-term discharge/buildup tests involving downhole pressure measurements in both the flowing wells and nearby shut-in observation wells are to be preferred. Relatively short-term cold-water injection tests are routinely carried out shortly after well completion. In recent years it has become common practice to employ downhole instruments, which record the pressure and occasionally temperature of the well feedzone during and after injection testing. The calculations presented in this report have shown that, for practical test durations, the downhole pressure response to a cold water injection test into a hot aquifer will consist of three portions when pressure disturbance is plotted as a function of the logarithm of time. The first is a straight-line portion of which the slope is dictated by the viscosity of hot water. This initial period lasts until approximately one wellbore volume has been injected. Next, when cold water begins to enter the formation, pressure begins to increase very rapidly. The slope of pressure-log(time) curve becomes very steep. Finally, at later times, another asymptotic straight-line region is approached. In the porous-medium case, or the fractured-medium case when its fracture spacing is not too great, the slope of this late-time asymptotic region will be governed by the viscosity of cold water. 2 refs., 2 figs.

7336 (GRSJ–8901, pp. 244-248) **Geochemistry and reinjection of waste waters in vapor dominated field.** D'Amore, F. (International Institute for Geothermal Researches, Pisa (Italy)); Nuti, S.; Francelli, R. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The geothermal power-plants in vapor dominated fields produce large quantities of condensate. These waters have high concentrations of ammonia, boric acid and sulfides, and are therefore potential pollutants of ground-water. The paper describes phenomena induced by reinjecting the condensates, which are the mixing of original deep steam and reinjection-originated steam, isotope fractionation of steam produced from reinjected water, effects of fluid redistribution/displacement where the areal gradients of isotopic composition and gas/steam ratio are present, and possible cooling of rock matrix. The effects of reinjection are overlapped by the natural temporal evolution of oxygen-18 content toward more negative values and gas/steam ratio toward higher values. Effects induced by fluid redistribution can also create serious problems in the practical use of these parameters alone as tracers. To assess all the effects induced by the injection and natural temporal evolution, numerous homogeneous values of the isotopic and chemical parameters should be monitored for the fluid of both producing wells and the injector. In spite of these limitations, oxygen-18-deuterium and gas/steam deuterium diagrams may permit a quantitative computation of the contribution of steam from the different sources and an assessment of eventual cooling effects in the reservoir matrix. 11 refs., 2 figs.

7337 (GRSJ–8901, pp. 388-391) **Statistical analysis of penetration rate and lost circulation in geothermal wells.** Maki, H. (New Energy Development Organization, Tokyo (Japan)); Kawano, Y. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The influence of lithology and/or regional characteristic's upon penetration rate is important to understand when estimating drilling costs and establishing project schedules. Since 1980, the New Energy Development Organization (NEDO) has been carrying out government-subsidized geothermal surveys throughout Japan. This report presents a statistical analysis of penetration rate and circulation-loss records from this program. The results are as follow: (1) The penetration rate generally decreases with increasing depth. (2) Average penetration rates for various rock type are: 23.31 m/day for Cenozoic sedimentary rocks and pyroclastic rocks, 20.71 m/day for plutonic and intrusive rocks, 17.96 m/day for Cenozoic volcanic rocks, 17.25 m/day for Pre-Tertiary sedimentary rocks, and 10.60 m/day for Chert. (3) Lost circulation occurred very frequently between 30 m and 100 m depth and drilling progress was usually slow in this depth interval. (4) Lost circulation occurred most frequently (and required the most time for recovery) in Cenozoic volcanic rocks. 4 figs., 2 tabs.

7338 (GRSJ–8901, pp. 326-329) **On the distribution of radiogenic heat producing elements and the derived geothermal model of the continental crust.** Cermak, V. (Eoetvoes Univ., Budapest (Hungary)); Bodri, L. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *International symposium on geothermal energy, 1988.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The conversion of compressional seismic velocity into heat production yields a general decrease of heat production with depth. This depth dependence needs not to follow exactly a simple exponential law. Summarizing the idea of the role of underground water circulation in the redistribution of the radioactive elements together with the finding of the principal disagreement between the extrapolated D-parameter (increasing with depth) and converted heat sources distribution (decreasing with depth), the model was proposed. The "original" distribution of heat sources was preserved in the lower crust and can be hardly identified from the near surface observations. If approximated by a general exponential curve, the D-parameter decreases with depth, i.e. deeper in the crust the heat production decreases more rapidly with depth than in the intermediate parts of the crust. This decrease is more pronounced within younger or high heat flow provinces than in old shields and platforms. At depth below 25-30 Km the contribution to heat flow is very small and there is no considerable difference between heat generation in the lowest crust and the uppermost mantle. The uppermost crustal rocks are enriched in radioelements. 9 refs., 3 figs., 1 tab.

7339 (GRSJ–8901, pp. 465-468) **Microearthquake observation system with portable digital event recorders. Principles and applications.** Tosha, T. (Geological Survey of Japan, Tsukuba); Nishi, Y.; Sugihara, M.; Ito, H. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The present condition of a digital data acquisition system incorporated with seismometers is presented, which has been in operation in the Takinoue geothermal field, Iwate Prefecture in Japan since 1982. Recent advances in MPU allowed the development of portable seismic recorders, and the arrangement of more seismometers are at present required to precisely analyze microearthquakes. The functions of each current hardware module and main interface modes of the software are presented. As an example of microearthquake studies, the typical E-W and N-S components of seismic wave traces and particle motions on horizontal plane in the Takinoue area are illustrated, and it is showed that the microcrack density just below a seismic station is possible to be estimated from time-delays in seismic waves. The arrangement of many recorders with a great dynamic range and broad bandwidth is required to define the detailed microcrack distribution, and in such case, the portable digital event recorder is suitable for field experiments. 12 refs., 5 figs.

7340 (GRSJ–8901, pp. 477-480) **Pressure/Temperature/Spinner Logging method and interpretation in geothermal reservoirs under two-phase condition.** Osato, K. (Geothermal Energy Research and Development Co., Ltd., Tokyo (Japan)); Okabe, T.; Takasugi, S; Muramatsu, S. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Pressure/Temperature Spinner (P/T/S) logging is very effective to obtain the important parameters of geothermal well. However, two-phase (liquid and steam) condition sometimes occur in the reservoir, and in this case, it is very difficult to analyze these parameters. This paper represents some of the research of two-phase condition analysis model. As reservoir part, the TOUGH simulator by Pruess was used. And as wellbore simulator part, the WELFX simulator by Schroeder was used. Relative permeability function of the reservoir is Corey's curves, and it is assumed that capillary pressure function is linear function. Input enthalpy is the value calculated by reservoir simulator and geothermal water feed zone consists of two feed points (1000, 960m depth). Porosity is 0.2. Flow rates were constant values (50, 100, 200ton/h) and only permeabilities were changed. Temperature were 200°C and 285.5°C. On these conditions, the model was analyzed by simulation. It must be fit the calculation result to real production P/T/S logging profile. The result shows the possibility of well testing interpretation under the condition of two phase production. 9 figs., 1 tab.

7341 (GRSJ–8901, pp. 426-429) **Exploration of the Mon ti Cimini Permit (Latium-Italy).** Carella, R. (AGIP, Geothermal Resources, Milan (Italy)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Exploration in the Monti Cimini permit (Latium - Italy) is being carried out by AGIP on behalf of a joint-venture with ENEL since 1979. The exploratory effort was based on two ideas: 1. There is no hydraulic connection between the Viterbo high and the downfaulted area to the East which could have a higher temperature because of the influence of recent volcanic activity in the Vico area. 2. The possibility of a deeper reservoir below the shallow one in the Viterbo high should be investigated. After carrying out a comprehensive set of a geophysical geochemical and temperature hole drilling, a deep exploratory well was drilled NE of Vico lake. It struck the permeable Mesozoic reservoir at 2600 m with a temperature of 220°C, proving that the exploration hypothesis was right. The formation is underpressured and substantial loss of circulation occurred; the reservoir could not be adequately tested, even if it produced fresh water intermittently. The area will be further investigated by drilling. The deeper prospects in the Western area will be tested by a 3500 m wildcat in 1989. 5 figs.

7342 (GRSJ–8901, pp. 430-433) **Salton Sea scientific drilling project, California, U.S.A.. Investigation of a high-temperature geothermal system in sedimentary rocks.** Elders, W.A.; Sass, J.H. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In March 1986, a research borehole reached a depth of 3.22 Km in the Salton Sea Geothermal System (SSGS). This was part of the Salton Sea Scientific Drilling Project (SSSDP). The purpose of this paper is to describe briefly the background of the project and the drilling and testing of the borehole, and to summarize some of the important scientific results. In spite of technical difficulties the SSSDP met or exceeded almost all of its initial objectives. We showed that although the rocks in the SSGS become indurated with depth, the permeability increases due to fracturing. Another lesson learned is the difficulty of dealing with zones of massive loss of circulation if it is necessary to drill deeper. We also learned that it is important to obtain as much core as possible. The results of logging above 300°C were disappointing. However better coring systems are needed to make coring of very hot wells economically feasible. Our experience with the SSSDP has convinced us of the importance of broadly based scientific study of hot deep wells to probe the roots of magma-hydrothermal systems. 15 refs., 2 figs.

7343 (GRSJ–8901, pp. 489-491) **Fracture evaluation in geothermal wells by the digital high temperature borehole televiewer.** Ito, H. (Geological Survey of Japan, Tsukuba); Kikuchi, T. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Experimental results of the Hijiori Project started in 1984 to develop the borehole televiewer (BHTV) technique applicable under more hot and deep conditions were reported. Preliminary data were gathered by use of an existing well of 1800m in depth in the Hijiori experimental site, and after drilling of new well subsequent to water injection into the existing well, fractures produced by hydraulic fracturing were logged by the BHTV. It was, as a result, concluded that two planar fractures existed before the injection test, new vertical fracture was created after the injection test, and since large amounts of fractures were observed by the BHTV around two wells, fluid was flowing through a lot of dendritic fractures. Prior to using, the heat resistance of the BHTV was so improved as to withstand high temperature in the wells. A digital data acquisition system was also developed to improve the reliability and quality of the BHTV data, and to digitize and display the data in realtime. 3 figs.

7344 (GRSJ–8901, pp. 417) **Practical problems in numerical simulation of geothermal reservoirs.** Menzies, A.J. (GeothermEx, Inc. CA (USA)); Autunez, E.U.; Sanyal, S.K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Numerical simulation is becoming increasingly important to the overall assessment of geothermal reservoirs as it is essentially the only tool available for simulating the future behavior of a reservoir in response to different production scenarios. The aim of numerical simulation is therefore to provide a computer model that mathematically describes the geothermal reservoir with sufficient accuracy so that the simulated future behavior can be used confidently as a prediction of the performance of the real reservoir. In setting up a computer model, it is first necessary to have a good physical understanding or conceptual model of the geothermal reservoir. The

conceptual model is based on a multi-disciplinary assessment of the physical and chemical data collected during both the exploration and development of a geothermal reservoir. The aim of this paper is to present the practical problems that sometimes arise when setting up a numerical model of a geothermal system and in using the model for simulating future changes in reservoir conditions. It should be emphasized that the problems discussed in this paper do not appear in every situation.

7345 (GRSJ–8901, pp. 469-472) **Seismic noise measurements in the eastern part of Hachimantai geothermal area, Northeast Japan.** Saito, T. (Iwate Univ. (Japan)); Sato, S. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

A seismic noise survey was carried out in the eastern part of Hachimantai geothermal area. For the location of observation sites, about 100 survey points were included in an area 11 km wide along the EW direction and 12 km long along the NS direction. The seismic noises were measured by 3-component seismometers with a natural period of 1 sec. All spectra of the seismic noise were classified into four types, type A has a single peak below 1.0Hz in spectra, type B has a single peak below 1.0 Hz and some peaks from 2 to 15 Hz. Type C has some peaks from 2 50 15 Hz and Type D has many peaks above 15 Hz. Large amplitudes of seismic noise were observed in the southeastern part of observation area, but these are caused by the stream of the Matsukawa river, human activity and existence of loose sediments. Also, the frequency of 2-15 Hz was dominant in these areas, and spectral types were B and C. The frequency of 2-15 Hz will be caused by existence of middle temperature hot water, and it may be assumed that the high frequency waves are generated by deeper geothermal activities. It is also assumed that the high frequency seismic noise happened to be observed, which was caused by the activities of the power plant and the steam supply system. 5 refs., 9 figs.

7346 (GRSJ–8901, pp. 554-556) **Fracture mapping in fractured reservoir on JMS's geothermal development.** Sato, Ko (Japan Metals and Chemicals Co., Ltd., Iwate). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The combination method of fracture mapping composed of three mapping methods was presented, which was accepted by Japan Metals and Chemicals Co., Ltd. (JMC) to evaluate fractured reservoirs. Firstly, about the detection of each individual fracture around a borehole, PTS(pressure, temperature, spinner) logging, and dip and strike logging by dip meter and borehole televiewer surveys were described. About the survey on extension of fractures, a multi-offset VSP(vertical seismic profiling techniques) and AE measurement added to a conventional tracer test and pressure interference test were described. Finally, about the recognition of a fracture pattern, it was pointed out that the regularity of fracture development should be estimated by a geological approach as well as new geophysical approaches by the VSP, dip meter and others. As an example, the relation between the fracture pattern and the geological development or history of a tectonic movement in the Kakkonda geothermal field was explained. 3 refs., 3 figs.

7347 (GRSJ–8901, pp. 594-597) **Temperature, pressure and kh distribution in the Kirishima geothermal field.** Yokoi, K (Nittetsu Mining Co., Ltd., Tokyo (Japan)); Kasagi, T.; Hazama, Y.; Nagao, S. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The results of geothermal resource researches performed in the Kirishima geothermal field since 1979 were reported. It was described that major permeable fracture about 1150m underground was identified by geophysical logs. The results of such various well tests were given, as pressure transient tests, production logs, pressure buildup tests, long term discharge tests, and pressure interference tests in the Ginyu area where a superior permeable reservoir existed. The temperature, pressure and kh (permeability-thickness product) distribution in the Kirishima field were illustrated based on the test results. Two ENE-WSW trending permeable zones were, as a result, detected in the Ginyu and Shiramizugoe area, and they were supposed to be separated each other because of the different reservoir pressures. The highest temperature area lay in the southeastern part of the area, and the constant temperature area of 232°C widely extended in the Ginyu area. The reservoir characteristics of both areas related each other, and also relate to the geological features of the Kirishima geothermal field. 4 refs., 10 figs., 1 tab.

7348 (GRSJ–8901, pp. 530-532) **Systematic approach to geochemical modeling of complex geothermal systems.** Klein, C.W. (GeothermEx, Inc., CA (USA)); McNitt, J.R. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Chemical of modeling of geothermal systems developed as a primary tool by GeothermEx, Inc., U.S.A. was introduced, which was capable of detecting, locating and quantifying the heating, cooling, mixing,boiling and condensing processes occurring in reservoirs. After the essential data were extracted from a vast geochemical database and verified, an easy-to-manipulate customized database including sample collection data was constructed, and various in-house software for an unit interconversion, data quality check, calculation of geothermometer data, calculation of reservoir steam quality and others were also provided. Various geochemical models for numerous hot water and steam/water geothermal reservoirs were developed, and the numerical modeling also allowed calculating Rayleigh condensation and evaporation effects on the composition of steam reservoirs. The geochemical modeling was practically applied to some geothermal development, and as an essential tool, also, used to study scale deposition processes during well production, boiling, cooling and injection of foreign fluids into the reservoir.

7349 (GRSJ–8901, pp. 543-546) **Method estimating bulk permeability from the conductive and convective heat discharges in geothermal fields.** Sekioka, Mitsuru (National Defense Academy Kanagawa (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The formula to determine the bulk permeability of rocks was derived by applying a simple columnar model to fissured basement rocks just above a geothermal reservoir. The following bulk permeability (k) formula was approximately derived as the function of a conductive heat discharge (Hd) transferred to the ground surface through the basement rocks overlying the reservoir, a convective heat discharge (Hv) transported through fissures within the rocks, and a rock thermal conductivity λ. $k = 9.37 \times 10^{-14}(Hv/Hd)\lambda$. The computation for eight geothermal fields in Japan provided reasonable values of the bulk permeability, and in the three of eight fields, the values roughly agreed with the bulk permeability data measured directly in the injection tests of boreholes under some assumptions and approximations. The extension of the formula for a two-phase flow through layered rocks was also given as a future subject. 6 refs., 1 fig., 2 tabs.

7350 (GRSJ–8901, pp. 539-542) **Magnetotelluric study of the geothermal system in Kuji volcano.** Mogi, T. (Kyushu Univ., Fukuoka (Japan)); Nakama, K.; Shimoizumi, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Kuju-Iwoyama, located northeastern part of the Mt. Hosshou in Kyushu, is an explosive crater of volcano and shows the most

intense geothermal activity in this area. There are many active fumaroles, hot springs, and alteration zones.The purpose of this study is to make clear the subsurface structure of the volcano area where shows such intense geothermal manifestation by using geoelectromagnetic method. The subsurface structure was assumed to be the simple two or three layer structure, the first layer has 50 to 300 ohm-m and its thickness is 40 to 200m. The resistivity values of the second layer vary at each site, but they are less than these of the first and third layer. The third layer has the about 300 ohm-m resistivity zones, less than 5 ohm-m in the second layer at the Kuju-Iwoyama area correspond to the existence of the mineralized hot water in these zones. And the fact that the resistivity of the first layer in this area is less than that of any other site shows that the rocks in the overburden layer has been altered because of the geothermal activity. 2 refs., 4 figs.

7351 (GRSJ–8901, pp. 547-550) **Numerical modeling for the method of ground charging.** Ushijima, Keisuke (Kyushu Univ., Fukuoka (Japan)); Mitzunaga, Hideki. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The method of ground charging survey using a well casing as the buried current electrode has been mostly used for geothermal investigations in Japan, while the original method has been developed in mining industry. However, it is sometimes difficult to determine geothermal fractures from the observed potential map only, then the apparent resistivity, the residual potentials and their digital filtered maps are computed by the various processing of the data. In the present paper, two steps of data processing for the enhancement of the anomalies, that are the residual anomalies and their digital filtering and examined based on the numerical data simulated by the finite element method (FEM) and the finite difference method (FDM). The digital filtering proposed in this paper is applied to the actual field data obtained in Kazuno area, Akita prefecture in Japan. Estimates of location and strike of faults by the method of ground charging are good agreement with those which were predicted by the geological and geophysical survey conducted in this area. 2 refs., 10 figs.

7352 (GRSJ–8901, pp. 551-553) **Colored magnetic map of Japanese Islands.** Okubo, Y. (Geological Survey of Japan, Tsukuba); Makino, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The 1:1,000,000 colored aeromagnetic map of the Japanese Islands and of the northern part of Japan superimposed on a bird-viewed topography are reported. The maps contain large amounts of information required to unravel the complex geological history of Japan. The lateral and regional variation of magnetic properties of granitic rocks can be identified in the map. In some places, Pre-Neogene tectonic divisions under alluvial plains are defined, and marine magnetic lineations crossing the Japan trench are also clear on the map. Curie depth was calculated, which described the depth to the inferred Curie point transition of magnetite, and since the exact value of the Curie point was unknown, the curie depth was compared with the borehole temperature data which indicated the conductive temperature to estimate the Curie point. The temperature gradients in a shallow zone were thus obtained, and heat flow was estimated from the temperature gradients and thermal conductivity. The heat flow map of the Japanese Islands estimated from the Curie depth map at the temperature gradient of 435°C/Curie depth and thermal conductivity of 2W/m-k is illustrated. 5 refs., 1 fig.

7353 (GRSJ–8901, pp. 561-564) **Two-dimensional interpretation of a high accuracy MT data at Iwama, Ibaraki prefecture.** Miura, Y. (Geothermal Energy Research and Development Co., Ltd., Tokyo (Japan)); Takasugi, S.; Kawakami, N.; Muramatsu, S. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Results of data analyses by one- and two-dimensional modeling program were reported using MT data measured at Iwama, Ibaraki Prefecture. For the evaluation of matching between calculated MT parameters and observed data in the two-dimensional model analysis, both pseudo sections (vertical axis; frequency, horizontal axis; distance) formed by mapping apparent resistivities and phases were compared resulting fine matching. Moreover, after the errors were grasped quantitatively by mapping residual errors in apparent resistivities to modify the underground resistivity model, the model could be modified successfully. The one-dimensional model analysis by the use of TE mode data was confirmed to be effective enough in this area where a two-dimensional underground resistivity structure was found. Since the data obtained by SHFMT(super high frequency MT) method were useful for the precise analysis of shallow resistivity structures, it was indicated that the SHFMT data were also effective to improve the reliability of deep resistivity structure interpretation. 3 refs., 6 figs.

7354 (GRSJ–8901, pp. 608-610) **Detailed gravity anomaly map in and around the Japanese Island.** Kono, Y. (Kanazawa Univ., Ishikawa (Japan)); Furuse, N. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1989. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Gravity stations in Japan were so heterogeneously distributed as somewhere only aligned along main roads and some were densely distributed in narrow regions. To improve these situation, we started gravity measurements not only in flat area but also in ragged mountain areas. Digital compilation of gravity data was also started with help of many institutions and organizations. They kindly offered unpublished data files as a form of printed matter or computer readable media. Total number of data is about 500,000 points, 80,000 points are on land and the others are ocean. Mean density of the gravity stations is about 25 points/100km^2. Gravity system is followed by the International Gravity Standardization Net 1971 (IGSN71). Our new map shows more detailed pattern of anomalies and strengthens contrast between locally positive and negative anomalies. At present, it is difficult to give comments for geothermal areas from the gravity anomaly point of view, but the map will be useful to understand basic features of geothermal fields in Japan. 1 fig.

7355 (GRSJ–8901, pp. 611-612) **Heat flow map of the Pacific Ocean and the adjacent continents and its geological-geophysical interpretation.** Tuezov, I.K. (Inst. of Tectonics and Geophysics, Khabarovsk (USSR)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Heat flow of the Pacific Ocean and the adjacent continents was investigated. There are two elongated belts of the increased heat flow values. The first belt, which may be called the West Pacific, strikes along the western part of the Pacific Ocean, including the Asia-Pacific transition zone and Australia. The observed heat flow values vary from -28 to 1214 mW/m^2 within the belt. The negative heat flow values are confined to the Kuril-Kamchatka trench. The second belt corresponds to the East Pacific Midocean Rise and its observed heat values ranging from -59 to 3065 mW/m^2. The East Pacific Belt of the increased heat flow values embraces the major part of the territory of the USA. The greatest positive heat flow anomaly of the belt is confined to the California Peninsula. Taking into account the sufficient number of evidences, testifying to the presence of a great lot of sources of the fresh lava flows and recent volcanic eruptions in the area of the East Pacific Rise, the heat sources are located at a comparatively shallow depth. As for the West Pacific Belt, the active volcanoes and magma chambers are mainly confined to the island arcs. It is affirmed by the less intensity and variation of the anomalies if to compare with the East Pacific Belt. The convective heat transfer plays the major part in the East

Pacific Belt, while the conductive one in the West Pacific. The Central part of the Pacific is characterized by heat flow values, close to the mean terrestrial ones. The depth and the morphology of the geothermal asthenosphere correlate well with those of the electrical asthenosphere and sufficiently differ from those of the seismic and density asthenospheres.

7356 (GRSJ–8901, pp. 613-615) **Submersible studies of hydrothermal activity in back-arc basins.** Yamano, M. (Univ. of Tokyo (Japan)); Fujii, N.; Nagihara, S.; Nagao, T. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Many back-arc basins are though to be formed by sea floor spreading similar to that at midocean ridges. Geothermal studies with submersible were made Geophysical and DSDP drilling results showed that in the Mariana Trough, the spreading has continued to the present. The highest value of heat flow reached about 2000 mW/m^2 and indicates the existence of hydrothermal circulation. A deep sea long-term temperature monitoring system has been developed and tested in dive studies with the submersible ALVIN in the Mariana Mounds area. Geothermal gradients on the mound, 5 m from the mound, and 20 m from the mound are calculated to be about 3.7 k/m, 1.2 k/m and 0.3 k/m respectively. The high heat flow on the mound is supported by advective heat transfer with upward pore-water movement. The okinawa Trough is also an active back-arc basin under extensional tectonics, and is thought to be in very incipient stage of back-arc spreading. Anomalously high and variable heat flow, 600 +- 400 mW/m^2, was observed, indicating that hydrothermal circulation is occurring in this area. Dive studies with the Japanese submersible Shinkai 2000 have been carried out in this area. Temperature measured by the probe inserted into the mound was much higher and ranged from 20 to 50°C. The probe was penetrated into normal sediment about 3 m apart from the foot of the mound. The obtained geothermal gradient was 16 k/m. Assuming that thermal conductivity of the sediment is 0.7 W/mK, heat flow amounts to about 11 mW/m^2. These results suggest that hydrothermal activity on this knoll was rather confined in a small area. 8 refs., 4 figs.

7357 (GSJ–8901) **Study on the deep geothermal resources survey technology.** Uchida, Toshihioro; Nishizawa, Osamu; Sugihara, Mitsuhiko; Kikucii, Tsuneo; Ito, Hisao; Sasada, Masakatsu; Takeno, Naoto. Geological Survey of Japan, Tsukuba, Ibaraki (Japan). Dec 1988. 259p. (In Japanese). Order Number DE89910150. Available from NTIS (US Sales Only), PC A13/MF A01.

This is an interim report of Sunshine Project Research and Development for 1987. Total 257 pages. Published by Geological Survey of Japan, Agency of Industrial Science and Technology, Japan. Items described are as follows: 1. Outline of researches in 1987. 2. Research on precise specific resistance analysis by deep electromagnetic method. 3. Research on water-bearing rock specific resistance under high temperature. 4. Research on Deep Cracked System Detecting Method. 5. Research on Fracture analysis in the vicinity of wells. 6. Research on the cracked reservoir layers. 7. Crack-forming simulation. 8.Research on crack filling minerals.9. Research on crack filling environment. 10. Research on cracked gases. 11. Research on geothermal reservoirs evaluation method. 114 refs., 145 figs., 23 tabs.

7358 (INS-R–345) **Isotopic geochemistry at Wairakei: Hydrological implications.** Stewart, M.K.;. Department of Scientific and Industrial Research, Lower Hutt (New Zealand). Inst. of Nuclear Sciences. Dec 1985. 19p. Order Number DE90612070. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

Deuterium measurements on geothermal water at Wairakei are consistent with the water being derived from rainfall which has percolated down from the surface. The oxygen-18 content, however, is enriched compared to average rainfall. This ^{18}O shift is due to isotopic exchange between water and rock at greater-than-explored depths. The magnitude of the shift implied that the mass ration (W/R) of water that has passed through the system (W) to the rock it has exchanged with (R) is about 1 assuming open (i.e. single-pass) conditions. (The ratio is about 2 if it has been a closed system, but this is thought to be less likely). The residence time of water underground cannot be determined from tritium and carbon-14 measurements at present, but arguments based on the argon isotope and deuterium contents suggest mean residence times of a few tens of thousand years. The water-rock ratio and large natural outflow of thermal water prior to exploitation are consistent with this. The ^{18}O content of the water has changed only slightly, and the D content not at all, during exploitation at Wairakei (measurements from 1963, 1974 and 1981). An initial tendency for the ^{18}O to increase because of steam loss (also shown more clearly by chloride), has been followed by decrease of ^{18}O (and chloride) because of dilution with infiltrating near-surface water in parts of the field. 19 refs; 5 figs.

7359 (LA–11103-MS) **Preliminary evaluation of thermal and nonthermal waters at selected sites in Panama, Central America.** Shevenell, L. Los Alamos National Lab., NM (USA). Nov 1989. 68p. Sponsored by U.S. Agency for International Development. DOE Contract W-7405-ENG-36. Order Number DE90003433. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

Thirty-one thermal and nonthermal water samples were collected in Panama by the Instituto de Recursos Hidraulicos y Electrificacion and analyzed by the Earth and Space Sciences Division at Los Alamos National Laboratory to evaluate the geothermal potential of four different areas. Chemical and isotopic analyses were performed on each sample. Because samples from several areas were submitted, the chemistry of the samples is varied, with total dissolved solids of thermal fluids ranging from 900 to nearly 10,000 mg/ℓ. All water samples studied are meteoric in origin, and none of the thermal waters exhibit an ^{18}O enrichment, which is characteristic of high-temperature isotopic, exchange between water and rock. At all four areas, calculated geothermometer temperatures within a reservoir of less than 160°C. 4 refs., 4 figs., 6 tabs.

7360 (LA-UR–86-2600, pp. 94-95) **High-temperature borehole measurements at Miravalles, Costa Rica.** Dennis, B.R.; Hanold, R.J. Los Alamos National Lab., NM (USA). Fal 1986. In *Los Alamos science, Number 14.* Order Number DE87003612. Available from NTIS, PC A06/MF A01.

While attending a 1984 Los Alamos workshop for Central Americans on geothermal energy development Costa Rican Institute of Electricity (ICE) engineers learned of the specialized instruments developed by the Laboratory's Earth Science Instrumentation Group to satisfy the diagnostic needs of the Los Alamos hot dry rock geothermal energy program. These unique logging tools are capable of operating at temperatures up to 300°C and pressures up to 15,000 psi for durations between 8 and 30 hours. The Costa Ricans explained their problem, and with support from the US Agency for International Development, these instruments were made available to ICE for downhole diagnostic measurements at the Miravalles wells. Los Alamos engineers and technicians overhauled a surplus well-logging rig and equipped it with 3 kilometers of special cable and a cablehead assembly, designed at Los Alamos, for interfacing with the downhole tools. A computer-driven data-acquisition system was installed in the logging cab. After being tested in a local geothermal well, the unit was shipped to Costa Rica together with logging tools for measuring temperature and pressure as a function of depth, flow rate throughout the production layer, and the contour and average diameter of the well casing and for collecting samples of brine from the reservoir without loss of dissolved gases.

1506 Environmental Aspects

Refer also to citation(s) 7277, 7335, 7376

1507 Products and By-Products

Refer also to citation(s) 7376

7361 (GRSJ–8901, pp. 47-50) **Extraction of gold and silver from geothermal fluid.** Brown, K.L. (Geothermal Research Center, Wairakei (New Zealand)); Roberts, P.J. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan),

10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

This paper describes the results of five experiments of the extraction of gold and silver from hydrothermal fluids with a experimental vessel settled up at KA35 well at the Kawerau geothermal field in New Zealand. The experimental vessel was designed to absorb the fluids from orifice plate controlled to be low pressure and had a chamber having within many collecting plates. The first experiment is a fundamental one in which a mild steel was used as metal collector plate. The rates of deposition of gold and silver on the plate were estimated. The second experiment showed that the rate on deposition of gold on the mild steel plate was controlled by the flux rate of hydrothermal fluid. The third experiment showed that a mild steel seemed to be better for the collection plate of gold and silver than copper and aluminium. The fourth experiment clarified that the activated charcoal was not suitable for the collector plate for gold and silver. The fifth experiment showed that a mild steel was better for metal collector than activated charcoal. 1 ref., 4 figs.

1508 Geothermal Power Plants

Refer also to citation(s) 7227, 7278, 7323, 7324, 7332, 8201

7362 (CRSJ-8901, pp. 168-171) **Heat extraction using a downhole coaxial heat exchanger. Preliminary considerations for power generation using a downhole coaxial heat exchanger system (1).** Morita, K. (National Research Inst. for Pollution and Resources, Tsukuba (Japan)); Sugimoto, S. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170--: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

A downhole coaxial heat exchanger (DCHE) is applicable to a wide variety of geothermal resources. However, previously proposed DCHE were not efficient in heat extraction performance, and thought to be not practical method. Therefore, authors investigated the effect of design parameters and operational parameters on the performance of the DCHE using numerical simulator. The thermal output of the DCHE increases significantly when convective heat transfer, particularly with phase change, exists in the formation. In this study, contribution of convective heat transfer in the formation on thermal output was taken into account by changing effective thermal conductivity of the formation. However, available data on effective thermal conductivity are few. It is necessary to accumulate data on in-situ convection or effective thermal conductivity for more accurate prediction of thermal output. It is important to perform a field heat extraction experiment since the effect of convection in the formation on thermal output of the DCHE is more directly and accurately evaluated by field experiment. 5 refs., 8 figs., 1 tab.

7363 (GRSJ-8901, pp. 7-14) **Research and development of down-hole pumps in the Sunshine Project in Japan.** Mori, Y. (Tokyo Institute of Technology (Japan)). Centre d'Etudes et Recherches des Charbonnages de France (CERCHAR), 92 - Rueil-Malmaison (France). 10 Nov 1988. (CONF-881170--: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Funded in the Japan's Sunshine Project, R and D of down-hole pumps was made and reported. The geothermal power generation gives expectation as an energy source with promising reserves spread throughout Japan. Over a half of those geothermal reserves contain 140 to 200°C temperature brine, which makes it necessary for hot brine to be investigated to be utilized. However in some of newly drilled wells, hot brine is too low in pressure to spout out with its self-pressure and must be pressurized to come up to the ground level, for which objective the down-hole pump is concluded to be the most promising after studies. Provided with such a down-hole pump, a binary cycle plant, to use brine thus pumped up and not to produce polluting gas, is considered to be an ideal geothermal plant. The No.1 pump continuously operated for 1,000 hours against 170°C brine, which is regarded to be the world's first success of motor-driven down-hole pump. The R and D of No.2 pump, to continuously operate 2,000 hours in laboratory and 5,000 hours in field against 200°C brine, was launched with important studies of insulator, oil, bearing, metal and construction. The binary cycle system, provided with the down-hole pump, in the production well, is expected to constitute an ideal geothermal energy system, without producing polluting gas, causing the deposition of scale in the well. 6 figs., 1 tab.

7364 (GRSJ-8901, pp. 156-159) **Reliability of geothermal power generation and experience of trouble.** Hibara, Y. (MHI, Nagasaki (Japan)); Tahara, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170--: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

A quarter century has passed since geothermal power station was put in practical use. Some geothermal power Plants were successfully operated over 20 years. On the other hand, many kinds of troubles have been experienced. Geothermal power generation needs no fuel, but plant should be operated with high reliability to generate power economically. Steam gathering system especially the steam separator in the hot water dominated geothermal field is a key factor to continue the successful geothermal power generation. Chlorides in geothermal steam carried over as fine drift of brine corrodes ferrous alloys. Washing operation, especially at full load, is effective to prevent output decrease by scale piling at first stage nozzles of steam separator but it must be done carefully. It is important to prevent severe geothermal power plants' troubles on only by careful material selection at design stage but also by timely inservice inspection and complete metallurgical inspection at overhaul. 3 figs., 2 tabs.

7365 (GRSJ-8901, pp. 172-175) **Power generation with a two-phase rotary seperator turbine. Preliminary consideration for power generation using a downhole coaxial heat exchanger system (2).** Sugimoto, S. (Mitsui Engineering and Shipbuilding Co., Ltd., Tokyo (Japan)); Morita, K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170--: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *International symposium on geothermal energy.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

A geothermal energy extraction system using a downhole coaxial heat exchanger was proposed. In the two-phase and steam turbine system, hot water is expanded adiabatically through a two-phase nozzle and high speed two-phase mixture is led to a two-phase turbine. Power is extracted and two-phase mixture is separated into water and steam by two-phase turbine. Then the steam is led to the steam turbine. Two-phase turbine and steam turbine system gives higher net power output and lower power generation cost in comparison with the multi-flash and steam turbine system. Consequently, the two-phase turbine and steam turbine power generation system was selected in this paper. Four effective thermal conductivities (λ) of the formation were assumed, and power generation costs were investigated for each λ. When λ is 20.0 Kcal/mh°C, the maximum net power output is obtained. In this case, reinjection temperature and total flow rate are 90°C and 1080 ton/h. When hot water temperature changes with time, a determination of the design point of hot water is important, since it greatly influences the construction cost of the plant and the power output, and consequently the power generation cost. Consequently, the optimum hot water design temperature which maximizes a total gain throughout the 15 year's payback period is needed. This design point temperature is equal to the hot water temperature after 6 year's plant operation, 198.6°C in the case described above. 4 refs., 6 figs., 3 tabs.

7366 (GRSJ-8901, pp. 176-179) **Economic analysis. Preliminary considerations for power generation using a downhole coaxial heat exchanger system.** Fujita, T. (Kawasaki Steel Corp., Tokyo (Japan)); Jinno, T., M Yoda, T.; Morita, K.; Yamada, K. Centre d'Etudes et Recherches des Charbonnages de France (CERCHAR), 92 - Rueil-Malmaison (France). 10 Nov 1988. (CONF-881170--: International symposium on geothermal energy,

Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Economic analysis of a downhole coaxial heat exchanger (DCHE, 3000m long) system for geothermal power generation was carried out. The four effective thermal conductivities (λ) of the formation were assumed, 2.7, 10.0, 20.0 and 30.0 Kcal/mh°C. Then the power generation cost was estimated for each λ. The design parameters of the power plants such as capacity, flow rates, reinjection temperature and hot water design temperature were determined by the previous reports. Construction cost per power plant capacity decreases significantly as λ increases. The cost for DCHE occupies 64 to 78% of the total construction cost. The annual values of power generation costs over 15 year's plant operation were calculated according to the present value method. The adjusted mean power generation costs are 119.0, 36.5, 20.2 and 14.7 yen/kWh respectively. The cost decreases greatly as λ increases. The result indicates that when λ is 2.7, purely conductive case, the power generation system seems to be impractical. It can be used only in isolated islands or inlands. When λ is 30 Kcal/mh°C, convective case, the power generation using the DCHE is comparable to new geothermal power generation system such as binary cycle power generation system or Hot Dry Rock power generation systems. The subsidy for well drilling reduces the power generation cost significantly. 3 refs., 3 figs., 5 tabs.

7367 (GRSJ–8901, pp. 184-186) **Development of a reaction type total flow turbine.** Yoshikawa, S. (Fuji Electric Co., Ltd., Kawasaki (Japan)); Ono, Y.; Shimoda, K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The development of a reaction type total flow turbine was described. In conventional systems, hot water from geothermal wells is separated into steam and hot water by means of a separator. However, the total flow turbine for power generation is driven by expanding hot water directly, thus improving the working efficiency of hot water. But, the total flow turbine has not been used for practical applications as yet because of technical problems. In the impulse type total flow turbine, the adhesion of water drops and water film cannot easily be removed from the rear edge of profile, which is a major reason why the expected performance cannot be obtained from the impulse type total flow turbine. In the Fuji reaction type total flow turbine, the moving blades are composed of an array of simple flat plates. This turbine has such features that hot water from the nozzle is expanded through the moving blades as if it flowed through one total flow nozzle, without changing the flow direction. This total flow turbine is simple in structure and allows a highly reliable design, realizing excellent peripheral efficiencies. The reaction type is ideally suited for total flow turbines using geothermal hot water containing a large quantity of impurities, because of eliminating the possibility of deposits of impurities. In order to evaluate the turbine, a model turbine of actual scale was manufactured and tested for a total of 1000 hours. The power was 21 kW with 1.7 atg of hot water. The turbine was operated without causing trouble. 5 figs.

7368 (GRSJ–8901, pp. 197-200) **Ohaaki station steam system.** Lee, K.C. (Design Power-New Zealand Ltd., Mellington (New Zealand)); Anderson, A.R. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Ohaaki Power Station is the second geothermal power station, the generation capacity of which is 116MW(e), in New Zealand. Steam-to set for the first turbine is scheduled at November 1988 and full operation at June 1989. This paper deals with the design, the specifications, equipment, materials and the pressure control system. Ohaaki Power Station is supplied with steam from the Broadlands geothermal field and reinject its separated water and condensate. The station has four turbo-generators; two high pressure (HP) back pressure sets of 11.5MW(e) each and two intermediate pressure (IP) condensing sets of 46.5MW(e) each. A total design steam flow of 710 t/h will be delivered from the steam fields. The HP exhaust steam will be stripped of condensate by mean of vortex separators and discharged into the IP system. The combined IP flow (two HP turbine exhausts plus IP steam direct from the steam fields) will then go to the IP turbines and thence to the condenser. The system had to enable a continuous flow to be drawn from the steam fields regardless of the station operating requirements. The system had, therefore, to be able to cope with virtually instantaneous changes in turbine demand and to vent part or all of the steam flow to waste for extended periods and to maintain design pressure in the IP system as the first pricrity. 5 refs., 1 fig.

7369 (GRSJ–8901, pp. 160-163) **From small capacity portable turbine to large capacity modular turbine.** Hibara, Y. (MHI, Nagasaki (Japan)); Tahara, M.; Ikegami, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The geothermal power generation has entered a steady growth period. The total capacity of geothermal power plants, including those under construction, in the world, attains to more than 5,000MW, with its annual growth rate of 16%. About 70% of those plants are less than 30,000kW in capacity. There are great needs for the modularization or shop assembly method, because they are high in cost for the erection. But actually, 10,000 to 30,000kW plants are constructed on site, availing of portable turbine generators. While there are still great needs for the small capacity plants. The portable turbine generator for the power generation is used in the small capacity wellhead pressure power plant, which concept has been however changed by the appearance of large capacity modular turbine. The worldwide tendency to the construction of about 30,000kW geothermal power plant, using the large capacity modular turbine, is being strengthened. While the construction of small capacity geothermal power plant, using the GEO-PACK, is expected to be accelerated in the geothermal field where the large capacity power plant can not be constructed. 10 figs.

7370 (GRSJ–8901, pp. 164-167) **Turbine materials for geothermal power generation.** Yamamoto, M. (Toshiba Corp., Tokyo (Japan)); Miyazaki, M.; Watanabe, O.; Amemiya, M.; Suzuki, Y. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The development and optimization of geothermal steam turbine material, based on the field test data, were presented. The turbine rotor material is of low alloy CrMoV steel and has been successfully operated over these twenty years, with a good anti-corrosiveness. The turbine blade is of 12Cr, with a high anti-corrosiveness. The turbine auxiliary such as condenser, refrigerator and piping has been with anti-corrosiveness for a long period, because of an appropriate material selection. As above, the development and optimized selection of turbine material, based on the field test data, have been promoted from the viewpoint of high resistivity required against the general corrosion, stress corrosion cracking and high corrosion fatigue strength. The measures from material aspect have contributed to the significant improvement on the geothermal power plant in reliability, combined with the design consideration, inclusive of the lowering in stress level and structural modification. The basic field corrosion test data are expected to be accumulated, in order to heighten the geothermal power plant in reliability. 4 figs., 1 tab.

7371 (GRSJ–8901, pp. 288-289) **El Salvador, geothermal development to the year 2000.** Vaga, D. (Comision Ejectiva Hidroelectrica del Rio Lempa, El Salvador (Mexico)); Campos, T.; Escobar, D. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In 1988, CEL has proposed a National Plan of Energy for the period 1988-2000, emphasizing an intensive utilization of the geothermal and hydro resources available for electric power generation. The total expected increase of installed capacity is in the order of 500 MW. The corresponding total investment would reach a figure of 700 millions US dollars. In relation to geothermoelectric expansion, the goal would be to install a capacity of 180 +- 20 MW, essentially through the accelerated development of 4 geothermal areas. Berlin, Chipilapa, San Vicente and Coatepeque; the latter being the only one where no drilling has been made as to actually have a direct identification or appraisal of the subsurface conditions. The parallel development of other identified areas, including the south-east zone of the Ahuachapan field, as well as experimental applications of binary cycles, are also considered basically as a support to accomplish the general task of the program. 2 figs., 1 tab.

7372 (GRSJ–8901, pp. 512-515) **Designs of wells and surface facilities. Preliminary considerations for power generation using a downhole coaxial heat exchanger system-(3).** Yamada, Y. (Sumitomo Metal Industries, Ltd., Osaka (Japan)); Taguchi, Y.; Fujita, T.; Yamaoka, K.; morita, K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The preliminary design of the power plant composed of fifteen downhole coaxial heat exchangers (DCHE) and a biphase turbine-steam turbine system was reported. The structure of the DCHE, in which a heat extraction medium was injected through an other annulus and recovered through an insulated inner pipe with no temperature lowering, was described. The characteristics such as a thermal conductivity, mechanical strength and pipe wall thickness required for the insulated inner pipe, and the design components such as dimensions and materials of the DCHE casing and inner pipe were examined. The distances between DCHEs, and a plant layout were also outlined. The unique possible designs of facilities such as a duplex stainless steel casing, normal steel inner pipe and turbine made of cheaper materials were given. Moreover, it was pointed out that the material as well as dimensions of the casing should be selected based on the compositions and temperature of geothermal fluid, and the long term insulation performance of the inner pipe should be evaluated. 3 refs, 7 figs, 4 tabs.

7373 (GRSJ–8901, pp. 504-507) **Operating experience of Milos Geothermal Power Plant with reinjection under high concentration silica and saltifield.** Tahara, M. (MHI, Nagasaki (Japan)); Sakanashi, H. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The Milos geothermal prospect located on one of the Cycladean islands of Greece represents a geothermal resource containing with a high temperature of 320°C and high silica content. The program of development was started with the drilling of a number of wells and progressed to the installation of a pilot-style 2MW(e) condensing power plant which went on-line in December 1986. The steam gathering systems was designed with steam separation pressure set to 8 bar abs. based on 700 ppm given as the design value for silica concentration in brine. However, the actual silica concentration turned out 1150 ppm, and so supersaturated silica precipitated heavily causing 80% pluggage of the reinjection line after three days operation. Hard scales were also formed in the hot water collecting tank constituting a part of the steam gathering system. Separation pressure was raised to 25 bar abs. so that temperature can be maintained at 225°C which corresponds to the saturated solubility of silica. On the other hand, the reinjection system was provided with vertical loops of piping to produce settling effects so that scales formed on pipe walls may not enter the reinjection well. Pots were provided in several places to catch the removed scale from pipewalls. It was confirmed that the silica deposition on brine reinjection line was minimized due to high pressure separation corresponding to the saturated solubility of silica. Although high purity steam than in other geothermal power plants were produce in Milos, turbine nozzle scaling was accelerated. This phenomenon was presumed by superheat steam due to throttling of turbine governing valve related to continuous partial operating. 3 figs, 1 tab.

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Refer also to citation(s) 7226, 7248, 7254, 7261, 7264, 7265, 7266, 7290, 7291, 7293, 7295, 7297, 7298, 7310, 7336, 7342, 7343, 7345, 7346, 7347, 7348, 7361, 7362, 7364, 7365, 7371, 7372

7374 (CRIE-U–87089) **Finite element analysis of liquid and vapor dominated geothermal reservoir. Fracture reservoir model.** Nakagawa, Kameichiro; Motojima, Isao; Komada, Hiroya. Central Research Inst. of Electric Power Industry, Abiko, Chiba (Japan). Oct 1988. 26p. (In Japanese). Order Number DE89910225. Available from NTIS (US Sales Only), PC A03/MF A01.

A subject of the utilization of geothermal energy is a natural geothermal reservoir so far, which exists in high temperature basement rock with high permeability. Meanwhile, in a hot dry rock power generation, artificial fractures are created in the hot dry rock though there is no natural reservoir, the thermal energy is extracted by circulating water through the artificial reservoir and is used for power generation. This paper concerns to the way to evaluated the effective energy extracted through the artificial reservoir and gives a numerical procedure to simulate the heat transfer in the hot dry rock. The hot fluid flows only through the fracture and follows Darcy's law. The heat transfer in the hot dry rock is expressed by the thermal conduction. The fundamental equations governing the motion and state of the fluid and the heat transfer are derived. The equations are solved numerically by means of the finite element method. 4 refs., 11 figs., 1 tab.

7375 (GRSJ–8901, pp. 187-190) **Flushing technique using liquid CO_2 for lower temperature geothermal wells.** Liu, Jiangang (Yunchen Bureau of Water Conservancy, Shanxi (China)); Zheng, Keyan. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

At recent years, a flushing method using liquefied CO_2 gas has been applying for lower temperature geothermal wells in China. Flushing of CO_2 is a combined flushing of physical and chemical methods. When the liquefied CO_2 is injected into a lower temperature geothermal well, the liquefied CO_2 is immediately heated and strongly vapored. It made its volume expanded rapidly. The steeply increased pressure acts to aquifer passing through casing pipe, and also mixes CO_2 gas and water to form two phase flow. Consequently, the strong air-lift pushes two phase flow rising and blowing out of the wellhead. After that the aquifer loses hydraulic balance, water from the aquifer recharges into the well rapidly under the action of large pressure difference. In case of flushing the well using CO_2-polyphosphate, the polyphosphates, such as sodium hexaphosphate $(NaPO_3)_6$, have three functions, that are complexing function, decrease surface tension and adsorption, in the flushing well. In the case of NO.3 geothermal well in Hebei province, this well was flushed by injecting hydrochloric acid with CO_2, and obtained a result increasing the flow rate from 256m^3/d before flushing to 508m^3/d. Flushing methods using liquefied CO_2 for lower temperature geothermal wells are suitable for various case. As a result of various tests for over 800 wells, the average yield increased from one to three times. 2 refs, 2 figs.

7376 (GRSJ–8901, pp. 195-196) **Protection of silica scale formation in the geothermal hot water.** Kawazoe, S. (Mitsubishi Heavy Industries, Ltd., Tokyo (Japan)); Sakanashi, H. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In order to avoid capacity decreasing of reinjection wells mainly caused with plugging of penetrative underground layers by precipitation of silica in reinjection water, a new silica removal process, which is a process by coagulation and precipitation of silica in the hot water, was developed. Relation between total silica removal ratio and elemental factors, such as coagulant, assistant coagulant and temperature, were researched with beaker test at a site, and following results were mainly obtained: polymerizing rate of dissolved silica was maximum at the pH of 7 to 9; in the coagulation and precipitation process, polymerized silica was more removed than dissolved silica; coagulant of aluminum compound showed the highest silica removal ratio at the pH of around neutrality and 80°C; among coagulants of organic polymers, cation organic polymers showed the highest total silica removal ratio; residence time of hot water in the precipitator takes about at least 1 hour judging form sedimentation curve. Based on the above test results, a silica removal process in the geothermal hot water was designed. Total silica concentration in the reinjected water decreased about 240 ppm which is equivalent to the saturated solubility of amorphous silica at 50°C. And so reinjection of water at 80°C caused no precipitation of silica in the penetrative underground layer. 1 fig.

7377 (GRSJ–8901, pp. 191-194) **Research on accumulating the harmful elements in geothermal water with aquatic plants.** Xing, Bingbing (Institute of Energy Sources (China)); Guo, Licong; Peng, Yongqing. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

As a result of component analyses for geothermal water, environmental pollution potentialities with use of geothermal water were generally recognized with high mineral material and high content of F^- in North China. Although injection methods are effective to eliminate the environment pollution of geothermal fluid, the technique and cost of injection are not practical at present yet for the technical level and financial capacity of China and other developing countries. Through the comparison of physical, chemical and biological methods, the biological method possesses low cost and great disposed quantity. After making the test for accumulating harmful elements in geothermal water with aquatic plants to find suitable one, nine kinds of aquatic plants, which can accumulate elements of Cl^-, Na^+ and F^-, were selected for further tests. As a test result, the aquatic plants which could comprehensively accumulate Na^+, Cl^- and F^- were Ceratophyllum demersum, Mymphoides pettatum and Spirodela polyrrhiza, the aquatic plant which could comprehensively accumulate Na^+ and Cl^- was Alternanthera philoxenoids, and the aquatic plant which could accumulate F^- was Lemna minor. These aquatic plants were considered as the optimized plants for purifying geothermal water. 4 refs., 5 tabs.

7378 (GRSJ–8901, pp. 249-252) **Experimental study on renewal of the reinjection of well.** Hirowatari, K. (Kyushu Electric Power Co., Inc., Fukuoka (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Experimental study on renewal of the reinjection well was performed. The reinjection simulation testing equipment was composed of five cylindrical columns, in which the various packing materials such as alumina balls and rock fragments can be packed. The Otake and Hatchobaru geothermal waters were flowed into the cylindrical columns. The adhesion of silica scale was concentrated at the first column and the permeability of the first column decreased to one hundredth compared with its initial value, when the pressure difference between the inlet of the first column and the outlet of the fifth column rose up to 5 kgf/cm^2. The change of measured water level with time in the well agreed with the calculated value from the numerical simulation. The area distance from the well bore where declined permeability and concentrated scale deposition had occurred, was limited near the well. The mechanical cleaning of scales and the hydrofracturing showed little effect on the improvement of injectivity. The maximum recovery in permeability was attained when the HF solution of 5 % used. The permeability increased more than 90 % of the initial value. The chemically treated columns recovered their permeabilities to 94 - 99 % of its initial value when the alumina ball was packed and 76 - 92 % when the rock fragment was packed. On the basis of the numerical simulation results, side-tracking was tried at OR-7 (350 m deep) in the Otake field. A new bore hole was drilled aside through the cut off section keeping a certain distance from the silica deposited well. The injectivity of the side-tracked hole was almost the same as initial value of the injectivity lost hole. 5 refs., 5 figs., 1 tab.

7379 (GRSJ–8901, pp. 201-204) **Numerical simulation of well characteristics coupled with steady radial flow in a geothermal reservoir.** Itoi, R. (Kyushu Univ., Fukuoka (Japan)); Kakihara, Y.; Fukuda, M.; Koga, A. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Output curves of flow rate versus wellhead pressure, referring to well characteristics, provide information on well productivity. The well characteristics are affected by reservoir parameters such as reservoir pressure, fluid temperature, and permeability-thickness product (kh). Geothermal wells drilled in a water-dominated reservoir discharge a steam-water mixture. Therefore, a two-phase flow wellbore simulator is a useful tool to evaluate the effects of these parameters on the well characteristics. Numerical simulations of well characteristics were carried out using the wellbore model. The fluid pressure decreases below the saturation pressure while flowing toward the well. The flow rates for larger values in kh show an rapid increase with a decrease in the well head pressure. When a single-phase fluid enters the well, a linear correlation is observed between the flow rate and the pressure. As the condition changed into the two-phase, the pressures decrease in a non-linear manner with an increase in the flow rate. This is because that the integrated value of total kinematic viscosity increases as the two-phase flow region expands in the reservoir. 2 refs., 4 figs.

7380 (GRSJ–8901, pp. 224-227) **Mutual interference among reservoirs for a complex model.** Fukuda, M. (Kyushu Univ., Fukuoka (Japan)); Itoi, R.; Koga, A. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In the planning stages of development of a new reservoir within, or adjacent to, already developing fields, one of the most important tasks is to estimate the effects of the new development on the existing production wells. In order to obtain basic data on mutual interferences among reservoirs, the changes in pressure and temperature of each reservoir with time are predicted for a complex model, with and without reinjection, and changing only two permeabilities of the aquifers. The results of the calculations are shown as follows. The pressures of the producing reservoirs show steep drops in the compressed water condition, and comparatively gentle drops in the saturated condition. While, the temperatures show smooth-curved drops in the both conditions. The heat extraction due to the production from a reservoir does not has so large effect on the temperature drop because of the heat supply from the reservoir rock, but the low temperature reinjection lowers the temperature. The permeability has a considerable effect on mutual interferences among reservoirs. 2 refs., 5 figs.

7381 (GRSJ–8901, pp. 236-239) **Analytical model for estimating terrain influence on reservoir pressures. Implications for Hohi Thermal area.** Pritchett, J.W.; Garg, S.K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In the natural state, it is sometimes possible to correlate stable underground reservoir pressures with the local ground surface elevation. That is, underground pressure at a fixed elevation will be higher under mountains than under valleys. A simplified linearized analytical model for these phenomena is presented. Observations of hot spring discharge rates and underground pressures may be used in connection with this model to obtain approximate regionally averaged horizontal and vertical rock permeabilities. The method is illustrated by application to the Hohi Thermal region located on Kyushu Island, Japan. Horizontal permeabilities in the Hohi area are extremely low, at least in a regional sense. This suggests that water motions are predominantly vertical, at least to the depths so far reached by drilling (3000m). Of course, these conclusions are only considered valid in a regional sense and do not preclude the existence of local relatively high-permeability subregions embedded in a larger area characterized by low average horizontal permeability. 1 ref.

7382 (GRSJ–8901, pp. 215) **Inverse problem of estimating some of the geothermal reservoir characteristics (Part 1).** Yoshimura, Yuzaburo (Japan Petroleum Exploration Co., Ltd., Tokyo); Nakagome, Osamu; Okazaki, Kaneo. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

To estimate the parameters of reservoir, its characteristics such as permeability and porosity, and past pressure, flow rate and other production data are simulated. Those properties are determined as those that give the best reasonable match between both the observed and calculated data. That process of parameter determination by match is widely known as a history matching, extensively studied in the petroleum engineering and hydrological field these two decades. The problem of history matching is basically a nonlinear optimum minimization problem, as a nonlinear operator equation Ka=u (where K:reservoir model-representing operator, a:reservoir parameter and u:observed reservoir data of model's output). Inversely, the history matching problem is precisely u/K=a. However, the obtainment of a is extremely difficult, because K is of spatially varying parameter reservoir models. The standard history matching approaches of spatially varying parameters often lead to an ill-posed problem, generally characterized by the nonuniqueness and instability of parameters to be estimated. To circumvent such an ill-posed problem, the minimax and linear programming, quasilinearization, optimum control approach, Kalman filtering method, maximum likelihood estimation, etc. were developed. More recently, a method based on a bicubic spline interpolation of permeability and porosity distribution, in a single-phase two-dimensional areal reservoir from pressure data, has been reported. 3 refs.

7383 (GRSJ–8901, pp. 379-382) **Some test results of the PTS logging tool as lost circulation detector under the drilling mud condition.** Hyodo, M. (Geothermal Energy Research and Development Co., Ltd., Tokyo (Japan)); Takasugi, S.; Okabe, T.; Muramatsu, S. Centre d'Etudes et Recherches des Charbonnages de France (CERCHAR), 92 - Rueil-Malmaison (France). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Lost circulation zones could be determined by updated PTS (pressure/temperature/spinner/) logging tool. Following two points were improved; (1) The spinner was separated 1.2m in position from the tool body by spacer bar. (2) The impeller was made 4.5 inches in diameter and the open style guide case was applied. And the spinner was found most effective in detecting lost circulations, and a lost circulation that could not be noticed while drilling, could be determined. The following may be cited as problems for the future; (1) Improving the spinner resolution at low revolution region. (2) Making not only the spacer bar but also the whole logging tool more slender and more compact in order to reduce the impact of fluid friction. This paper represents some of the research achievements included in the Research and development of lost circulation techniques in geothermal wells. 6 figs.

7384 (GRSJ–8901, pp. 387) **Stability of highly deviated boreholes in geothermal field.** Yoshimura, Y. (Japan Petroleum Exploration Co., Ltd., Tokyo); Inowaki, R. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

As the number of drill holes penetrated from the same site has been increasing recently, it has been demanded that the opportunities to complete higher deviated wells. Increasing of the inclination of the well could lead us to the various troubles such as enlargement of borehole, drillpipe stacking, poor cutting transport and so on, while drilling. Because the excessive inclination of the well causes the borehole collapse, the evaluation for the stability of the well must be important. The borehole failure can be estimated by the computed stress field around the borehole, using the linear elastic and isotropic model for the subsurface formation suggested by Aadnoy and Chenevent (1987) and the assumption of the in-situ stresses. So, we consider about the shear effects and tensile failure around the borehole using the equation of Von Mises Yield condition. We assumed that the in-situ stresses causing the fracture of the borehole are principal and directed horizontally and vertically. We can predict the relationship between the stress field and the well deviation theoretically using the linear elastic and isotropic model for plane-stress.

7385 (GRSJ–8901, pp. 392-397) **Review of geothermal drilling operations. Toward more effective operations.** Rowley, J.C. (Los Alamos National Lab., NM (USA)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Drilling operations for geothermal development have usually been adaptations of oil field or mining experience and equipment. The subsurface conditions, rocks, and environment in geothermal reservoirs are quite different. Mining exploration drilling equipment, primarily diamond core drills, have been a primary method used for geothermal exploration, and this equipment has been used very successfully worldwide. Geothermal drilling projects are plagued by two major problems: (1) lost circulation and (2) limited drill bit performance. New technology and operating approaches are available (lightened drilling fluids) or in progress (down hole plug setting tools and chemicals) to reduce time and costs due to lost circulation. New polycrystalline diamond compact materials and bit designs are currently in development that offer large increases in bit life. An average penetration rate of 4.5 m/h(15 ft/h) is recorded for geothermal and crystalline rock well drilling. 17 refs., 5 figs., 1 tab.

7386 (GRSJ–8901, pp. 351) **Studies on the conveyance and distribution of geothermal hot water (Part 24). Results of effective geothermal water supply system at Shuzenji hot springs.** Hosoya, N. (Hot Spring Research Center's Inst., Tokyo (Japan)); Nakajima, K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Shuzenji spa is situated on the northern part of Izu Peninsula. About 73 thermal springs (drilled wells) with a total discharge rate about 10001/min. are scattered along the Katsura River. Total number of wells and total discharge rate of the water had increased with the increase of demands for the water due to the development of spa, and then, marked drawdown of thermal water level had occurred. The lowering of the water temperature and decrease of the content of major constituents (Cl^- and SO_4^{2-}) had been observed. It was clear that these changes had been caused by the exhaustion of thermal water resources. Recently, an effective thermal water supply system appeared on the stage as the measures for the exhaustion of thermal water resources. This system, which is characterized by the control of the pumping-up of thermal water and its efficient supply and distribution to a wide area through circulating

pipe line net system, was constructed in 1981, and since then, total discharge rate has been controlled under about 10001/min. It is worthy of special mention that the rise of pumping water level and water temperature have been observed after 1981. This report presents the status of the restoration of thermal water resources and economical effects by this system including the analyses of the relationship between the consumption rates of the water and number of the guests in the spa.

7387 (GRSJ–8901, pp. 375-378) **Economic modeling of HDR energy system.** Kappelmeyer, O. (Geothermik Consult GmbH, Duesseldorf (West Germany)); Smolka, K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The components of a HDR energy production system were defined and compiled to a structure diagram in which the various interdependencies are considered. The natural parameters determining the HDR potential as there are: geothermal gradient, rock permeability, fissure transmissivities, in-situ stress field, structure (fracturation), hydrology in the fractures, have to be determined by in-situ measurements in boreholes. The central part of a HDR system is the artificially stimulated heat exchanger system which is the HDR reservoir. The thermal power of this reservoir is given by its thermal effective surface area and the natural rock temperatures at the depth of the reservoir. For an economic evaluation it is necessary to consider water losses during circulation. In the course of heat extraction from the rocks the temperature of the circulating fluid will be reduced and the thermal power diminishes. The cost for HDR reservoir generation is determined by the amount and the geometrical configuration of the in-situ stress field. Considerable expenses may arise due to the hydraulic impedance in the circulation loop. 3 figs.

7388 (GRSJ–8901, pp. 383-386) **Estimating of equilibrium formation temperature by curve fitting method.** Chiba, M. (Geothermal Energy Research and Development Co., Ltd., Tokyo (Japan)); Takasugi, S.; Hachino, Y.; Muramatsu, S. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Determination of true formation temperature from measured bottom-hole temperature is important for geothermal reservoir evaluations after the completion of well drilling. However, the original temperature field around a borehole is disturbed by circulating mud during drilling, and it takes a considerably long time to reach temperature equilibrium between the formation and drilling mud after drilling and mud circulation has ended. Several mathematical models for bottom-hole temperature stabilization have been proposed for estimation of formation temperature from short-period logging data after cessation of circulation of drilling mud. It has turned out that the non-linear least square fitting technique is applicable as a simple and relatively reliable method. It is necessary, however, that the thermal diffusivity of rocks, K, which is an important parameter, be determined as far as possible from the physical properties of cuttings of the formation in hand. The temperature recovery data, used in verifying the non-linear least squares fitting technique, were presupposed to be analyzed by the Horner-plot method. 4 refs., 2 figs., 3 tabs.

7389 (GRSJ–8901, pp. 359-362) **Microseismic mapping of an HDR reservoir.** House, Leigh (Los Alamos National Lab., NM (USA)); Fehler, Michael. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

An Hot Dry Rock (HDR) reservoir was created at Fenton Hill, New Mexico by a large volume (more than 20,000 m^3) hydraulic injection, termed the Massive Hydraulic Fracture (MHF), done in December, 1983. Since the MHF, four more large fluid injections have been done at Fenton Hill, and each produced thousands of microearthquakes. The major results of characterizing that HDR reservoir, by analysis of the induced microseismicity from the MHF, are described here. The most fundamental information about the induced microearthquakes are their locations. Several studies have shown that the distribution of microearthquakes encompasses the system of fluid flow paths created by the hydraulic injection. In addition to locating them, the orientations of the surfaces that slipped during the earthquakes can be determined. This information also shows about the joints and fracture system created, and can be used to estimate earth stresses in the reservoir region. 12 refs., 2 figs.

7390 (GRSJ–8901, pp. 363-366) **Simulation of hydraulics fractures for hot dry rock.** Kuriyagawa, M. (National Research Institute for Pollution and Resources, Tsukuba (Japan)); Matsunaga, I.; Yamaguchi, T. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The Japanese hot dry rock project started at Yakedake field in the Gifu Prefecture in 1977. In 1980 and 1981 five boreholes were drilled to a depth of 300 meters. Two boreholes, HY-2 and CW were drilled in 1982 and 1983. Hydraulic fracturing tests were repeated to get information on fracture direction and radius. The fracture radius was calculated by two different approaches based on the stress balance and heat and mass transfer respectively. Hydraulic fracturing experiments were repeated using HY-2 at a depth from 142 to 283 meters. A dual packer was used to isolate an openhole section. Water injected into the borehole HY-2 is the sum of water stored in the fracture, that stored in the wellbore and that permeated into the formation. The fracture volume, with the relation for fracture radius, was calculated. An approach, which is based on non-linear heat and mass transfer, is introduced to estimate the fracture radius. The computer code used is FEHM (Finite Element Heat and Mass Transfer Code). 4 refs., 8 figs.

7391 (GRSJ–8901, pp. 367-370) **Evaluation of hydraulic properties of the artificial subsurface system in Higashihachimantai geothermal model field.** Hayashi, K. (Tohoku Univ., Sendai (Japan)); Abe, H. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In the Γ-Project, Tohoku University, a subsurface system, which consists of an artificial, globally flat crack and two wells, were successfully constructed as designed. After the connection of the two wells through the reservoir crack, experiments to examine the hydraulic properties of the subsurface system were performed. The experiments were the transmissivity tests, the circulation tests and the tracer test. The water pressure and velocity distribution of the flow in a penny shaped crack with an inlet and an outlet are analyzed, where the water loss during the circulation is appropriately taken into account. The transmissivity can be obtained by the straight forward manner proposed by Jung (1987). Based on the analysis just stated, the flow impedance can be expressed as a function of the crack size, the transmissivity and the location of the inlet and the outlet. As to the evaluation of the area of effective heat exchange surface, the time variation of the tracer concentration at the outlet during the tracer test is firstly simulated based on the analysis of the flow stated before. 5 refs., 8 figs.

7392 (GRSJ–8901, pp. 371-374) **Rock fracture mechanics for design and control of geothermal reservoir.** Takanohashi, M. (Japan Metals and Chemicals Co., Ltd., Iwate); Niitsuma, H.; Takahashi, H. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The acoustic emission technique (AE) is utilized to map subsurface fractures and to evaluated their shape, size and orientation in geothermal reservoirs and other geological structure. The technique is also used as a powerful tool for mapping hydraulically induced fractures in hydraulic fracturing as well as for the prediction of lost circulation during drilling. This paper describes some results of the AE measurements in the Kakkonda geothermal field, Iwate Prefecture, Japan. Hydraulic fracturing of a production well was effected in the Kakkonda field. The AE technique was introduced to evaluated and control the stimulation. It was assumed that the distribution of a created reservoir cloud be mapped by AE source location and the efficiency of the stimulation could be determined from AE activity. Reservoir stability control has been successfully accomplished through valve operation based on the results of AE analyses. The evaluation of geothermal reservoirs based on rock fracture mechanics using the AE technique reveals rock fracture properties, fracture shapes and the characteristics of subsurface fractures in geothermal fields. Therefore, a predetermined quantity of steam can be stably obtained. 8 refs., 8 figs.

7393 (GRSJ–8901, pp. 492-495) **Application of rock fracture mechanics to HDR reservoir design. Overview of Γ-project, Tohoku University.** Nakatsuka, K. (Tohoku Univ., Sendai (Japan)); Takahashi, H. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In order to develop a design methodology of geothermal reservoir cracks, Γ-Project (5 year project, 1983-1988) was started at Tohoku University. In this project, a basic fracture mechanics model of geothermal reservoir cracks was demonstrated and its validation was addressed both theoretically and experimentally. Γ-Project was divided into three research phases. As phase 1 of the project, hydraulic fracturing experiments using the 10 m size large rock specimen was performed at Field Laboratory, Tohoku Univ. The crack growth observed was examined in terms of rock fracture mechanics, and the size of the hydraulically created cracks was estimated by using the newly proposed crack growth model and compared with the observed crack growth. In phase 2, four exploration wells were drilled by continuous coring at Higashi-Hachimantai field, where welded tuff layer of more than 150 m thickness is distributed from 250 m to 420 m deep, and a hydraulic fracture test was performed. In phase 3 of this project, in order to investigate hydrothermal effects on HDR reservoir system in heat extraction stage, autoclave test facilities were developed, and rock fracture mechanics had been examined under the confining pressure of 40 MPa. 11 refs., 4 figs., 1 tab.

7394 (GRSJ–8901, pp. 473-476) **Geothermal well drilling at productive zones in the Kirishima geothermal fields.** Hauruta, S. (Nittetsu Mining Co., Ltd., Tokyo (Japan)); Hagino, N.; Nakao, K.; Iijima, A.; Sato, N. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Geothermal well drilling at productive zones in the Kirishima geothermal fields was done with a repetition of trial and error. Unless the cutting are lifted to the ground and enter fissures of the lost zone, the drilling must be given up because of stuck pipe. Then mud fluid is used. But those zones are echelon arrangement in fault system and has a zone, containing several small fractures, as a geothermal reservoir, where the occurrence of many complete circulation losses becomes problematic in costing. Different trials and errors were repeated to complete the drilling against the above fault condition. At the first trial stage, fresh water was used. Though having no bad effect on the geothermal reservoir, it spends a lot of time for storing fresh water and can not have cake prevent the bore hole wall from caving. Then, mud fluid is used again. Next, hot water from the discharging well was tried to be used. It has the merits of being low in cost, without using mud fluid accordingly without loss due to it, and having no bad effect to geothermal reservoir, while having the demerits of being unable to avoid the collapse on the bore hole wall and heightening the slip velocity to lift the cuttings. Depending upon the conditions, the above different methods are to be used in combination. 2 refs., 3 figs.

7395 (GRSJ–8901, pp. 481-484) **High pressure water jet drilling in hot dry rocks.** Kiyohashi, H. (Tohoku Univ., Sendai (Japan)); Kyo, M., Sekiguchi, R.; Matsushita, Y. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

As a part of studies to verify whether analysis results of jet drilling and results obtained by imitation rock experiments could be applied to natural hot dry rocks, the effects of continuous water jet speeds, rock temperatures and physical properties of specimens on breaking patterns and efficiencies were examined using such four kinds of specimens as Indian blue granite, Indian white sandstone, Komatsu andesite and Ogino tuff. Experiments were carried out under such conditions as specimen temperatures from room temperature to 600°C and jet speeds of 130-400m/s. Braking patterns and figures of the specimens were so complicated that breaking efficiencies defined by a drilling depth and jet static pressure were widely scattered. Various shapes of cavities were observed on the specimen surfaces, and in some cases, specimen crushing also happened with vertical fracture surfaces. Regression equations between the drilling depths and jet static pressures were adopted as experimental equations, and dimensionless correlation equations between the drilling depths and other parameters were also derived. 11 refs., 2 figs., 1 tab.

7396 (GRSJ–8901, pp. 405-406) **Present status of exploitation of Dogger for direct use of geothermal energy in France.** Gerard, A. (Institute Mixte de recherches geothermiques, B.R.G.M. (France)); Fouillac, C. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The Dogger reservoir in France is mainly exploited in the central part of the Parisian basin. 54 power plants were built, mainly in 1979-1984, on a surface of approximately 10^4 km^2. They produce a mean of 10 MW thermal each used for space heating and they allow a total petroleum saving of 200,000 E.P.T. (Equivalent Petroleum Tonnes) each year. The reservoir is inside carbonates rocks, situated at a mean depth of 1800 m. The fluid has a mean temperature of 75°C and a total salinity between 6 and 35 g/l. The temperature, except some local anomalies, depends mainly form depth with a general gradient of 3.5°C/100m. Difficulties occurred since 1985. The most severe one is the decrease of the ratio (Cost of energy/Inflation rate). Beside this, some technical problems related to corrosion and sulfides scaling in some parts of the reservoir have appeared during the last three years. Various research works and demonstration projects are presently carried out in order to solve the technical difficulties. They include: Performances evaluation of treatments using chemical additives injected at the bottom of the production wells and so on. 3 figs.

7397 (GRSJ–8901, pp. 508-511) **Development of highly insulated inner pipe for downhole coaxial heat exchanger.** Morita, K. (National Research Institute for Pollution and Resources, Tsukuba (Japan)); Morimoto, M.; Mukai, R. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In order to develop a high performance small diameter highly insulated inner pipe for a downhole coaxial heat exchanger, field heat extraction experiments were performed, initiating design and manufacturing of prototype models. Operating conditions and performance requirements of the insulated inner pipe were selected as follows; the well inner diameter of 80 mm, the maximum hanging depth of 500 m or larger, the maximum temperature of 300°C and

the overall equivalent thermal conductivity of 0.3W/(m.k) or less. The vacuum double pipe system with the packed powder insulator was employed for thermal insulation, providing with the best heat insulating performance. Two types of prototype models were manufactured. The outer pipe of both models was made of a carbon steel pipe equivalent to API H-40, and the inner pipe of a stainless steel equivalent to JIS SUS 304 or a carbon steel equivalent to JIS STPG38 respectively. As a test result, the values of the overall equivalent thermal conductivity of both models increased as the temperature rises resulting in lower thermal insulation, and were found to be about 0.017 W/(m.k) even in case the temperature of inside surface was 300°C, assuring sufficiently high thermal insulating performance. A further examination for the corrosion resistance and strength of these models are required prior to applying in practice. 4 refs, 6 figs, 1 tab.

7398 (GRSJ–8901, pp. 516-517) **Heat extraction experiment using heat pipe in geothermal field.** Yuhara, K. (Kyushu Univ., Fukuoka (Japan)); Zhou, P. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In order to make clear the problems encountered in the use of a heat pipe to extract heat energy, the effects of the heat supply efficiency in a geothermal system, temperature difference between a heating and cooling zone, and heat insulation between a evaporator and condenser were investigated. A short heat pipe of 150cm in length and 2.72cm in bore was used in experiments. In a laboratory, heat transfer rates were measured inserting the evaporator into electrically heated sands with difference and heat insulation were examined using silicone oil as a heating material. Field experiments were carried out in a geothermal field in Oita Prefecture. A numerical conduction model was used to analyze temperature distributions under the assumption of a constant temperature heat source, and calculated heat transfer rates were larger than those obtained from the field experiments. This might be explained as the result of a contact resistance on the evaporator surface, and it was hence suggested that the resistance should be carefully minimized in further applications of heat pipes. 5 refs., 2 figs.

7399 (GRSJ–8901, pp. 572-575) **Effects of heat transfer on water steam flow through a porous medium.** Niibori, Y. (Tohoku Univ., Sendai (Japan)); Chida, T. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

As a part of the theoretical studies of water-steam flow in geothermal reservoirs, a new mathematical containing a function between an over-all heat transfer coefficient and water saturation in steady state was proposed, and the effects of heat transfer on water-steam flow were examined in detail comparing calculation values with experimental ones. The theoretical equation was derived supposing a cylindrical porous medium under following assumptions:the temperature of injected water was sufficiently near the boiling point, the temperature of a thermostat was constant and higher than the boiling point, and fluid flow obeyed Darcy's law. A glass beads bed of 9.5mm in radius was used as a porous medium in experiments. As a result, the proposed mathematical model could approximately describe the water-steam flow through the porous medium. The apparent thermal conductivity given as a non-linear function of saturation was an important factor to estimate heat transfer in water-steam flow,and the effects of steam phase on the apparent thermal conductivity was remarkable in the region of water saturation smaller than 0.2. 9 refs., 10 figs., 1 tab.

7400 (GRSJ–8901, pp. 579-582) **Three pressure build-up behaviors of M-7, a dry steam well in Matsukawa, Japan.** Hanano, Mineyuki (Japan Metals and Chemicals Co., Ltd., Iwate); Sakagawa, Yukihiro; Saida, Toshihiro. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The results of three pressure build-up tests were reported, which were performed annually to improve the understanding of the physical mechanism of geothermal reservoir by the use of M-7 dry steam well in Matsukawa from 1986 to 1988. After the close of a well main valve, pressure build-up behavior was monitored at the well head by a burdon tube pressure gage for 176-290 minutes, bottom hole shut-in pressures were estimated by compensating the well heat shut-in pressures, and kh (permeability-thickness product) values and skin factors were calculated by ordinary horizontal radial flow equations. As a result, the pressure build-up data of three tests observed at the well heat showed clear semi-logarithmic straight lines. Apparent condensation effects were observed at a same shut-in pressure in both 1986 and 1988, while the pressure build-up data in 1987 was more linear than those of others. This meant that damage was less in 1987. Steam temperature in the vicinity of the well was constant through Oct. 1986 to Feb. 1988, and the change with time of the magnitude of damage was observed as the change of the skin effect. 10 refs., 3 figs., 1 tab.

7401 (GRSJ–8901, pp. 586-589) **Hydrothermal convection in geothermal reservoirs with sloping basement aquitards.** Yano, Y (Geological Survey of Japan, Tsukuba). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Since the influence of a reservoir bottom slope itself had not yet been systematically clarified, the preliminary results of a theoretical study and numerical simulation for natural convection patterns in inclined bottom reservoirs were reported. The mass flux and temperature distribution patterns calculated by a finite-element two-dimensional single-phase simulator were illustrated in simple base cases. Various parameters affecting the numerical calculations were shown, and to examine the influence of parameters, some types of patterns were calculated in cases where different convection driving mechanisms were combined. Permeability most important among rock properties, the influence of a caprock, three-dimensional effects important for real reservoirs, and point heat sources affecting the flow at an early stage of transient convection were examined. It was pointed out that the significance of these parameters must be established before the simulation is applied to real geothermal fields. 6 refs., 6 figs., 2 tabs.

7402 (GRSJ–8901, pp. 590-593) **Pressure interference data analysis for two-phase geothermal reservoirs.** Grag, S.K.; Pritchett, J.W. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The applicable limits of the preceding theory were defined, which was proposed for the practical analysis of the pressure signal expected at an observation well to yield reservoir transmissivity and connectivity despite two-phase effects. A numerical reservoir simulator was used to generate a series of drawdown/buildup histories. The detailed examination of these simulated pressure interference histories showed that the theoretical method could always be used to provide a first estimate for reservoir transmissivity. However, if the two-phase zone created during drawdown was remarkably large, then an apparent mass flow rate was a small fraction of an actual production rate, and in this case, the analytical method so yielded only a first rough estimate for reservoir transmissivity. The present numerical results suggested that the buildup response in the observation well, after the return of the reservoir to single-phase conditions, obeyed a superposition principle. Buildup data could, hence, be used to check the consistency of formation properties derived from the analysis of drawdown pressure. 4 refs., 1 fig.

7403 (GRSJ–8901, pp. 598-601) **Optimizing injection-production well pattern in hot water dominated geothermal reservoir.** Omuta, H. (Japan Oil Engineering Co., Ltd., Tokyo);

Obara, K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170--: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The optimization of an injection-production well pattern was examined based on the quantitative study about the effects of reinjection water on production water. Reservoir characteristics distributions and reinjection water flow behavior between the injection and production wells were monitored by a tracer test, and the effects of reinjection water on the pressure and temperature of production water were examined by a numerical reservoir simulation model. The pressure response induced by water production or injection was transmitted into the reservoir rather rapidly and widely, however, the temperature change induced by water injection was not transmitted so rapidly as the pressure response. The reservoir was cooled gradually with the advance of injected water front. In designing the optimal reinjection system, it was thus most important to control the water replacement front and its velocity, and to minimize the temperature effect of reinjection water on production water. Combined use of the tracer test and simulation was proved to be remarkably helpful in evaluating a reservoir heterogeneity and in optimizing the well pattern. 3 refs., 9 figs., 1 tab.

7404 (GRSJ-8901, pp. 500-503) **Experimental study on transportation of two-phase mixtures through horizontal and inclined pipes.** Aikawa, K. (Mitsubishi Heavy industries, Ltd., Tokyo (Japan)); Soda, M.; Matsuo, T.; Tahara, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170--: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

To realized the steam-water mixture transportation, clarifying some problems such as flow stability and increase of pressure drop, steam-water mixture tests were carried out at actual geothermal fields to investigate the characteristics of the mixture transportation. And an air-water mixture test was also carried out in a wider range of the inclination of a pipe to investigate the effect of the inclination. The steam-water tests were carried out at Otake and Hatchobaru. In both tests, the mixtures of steam and hot water coming up from the wells were introduced into the test section under the condition varying in a pressure from 0.20 to 0.60 MPa and a mixture velocity from 4 to 58m/s. The flow conditions in the tests were plotted on the Baker's chart and mandhane's. As a result, the flow patterns of the steam-water mixture and the air-water mixture approximately agreed with the Mandhane's chart. The measured void fraction was higher than the calculated value by the Lockhalt-Martinell method. The frictional pressure drop could be predicted by the L-M method. Although this prediction gives slightly larger values they are on the safety side in a design work. 6 refs, 7 figs, 2 tabs.

7405 Thermodynamic calculations of calcium carbonate scaling in geothermal wells, Dixie Valley geothermal field, U.S.A. Reed, M.J. (Geothermal Technology Div., U.S. Dept. of Energy, Washington, DC (US)). *Geothermics (USA),* 18(1): 269-277 (1989).

Wells in the Dixie Valley geothermal field of central Nevada intercept a fracture-dominated hydrothermal system at depths of 2.5 to 3 km. The reservoir water is a dilute sodium-bicarbonate-chloride type of solution thought to be in equilibrium with quartz, calcite, chlorite, and albite. Fluid sampling and chemical analysis of production during an early flow test gave remarkably low calcium concentrations. Thermodynamic calculations of mineral stability in the presence of the reservoir water indicate that five times the amount of calcium measured in fluid reaching the surface is actually in solution in the reservoir fluid. Approximately 80 percent of the calcium is lost as calcium carbonate scale on the well casing before the fluid reaches the surface. The results of thermodynamic calculations compare well with the scale-volume measurements of Benoit.

1510 Direct Energy Utilization

Refer also to citation(s) 7227, 7232, 7296, 7385, 7395

7406 (ETDE-mf-0732349) **Investigation of the possible uses of high-salinity thermal water for geothermal energy recovery. Final report.** Althaus, E.; Friz, A.; Karotke, E.; Ott, G.; Pernklau, E. Karlsruhe Univ. (T.H.) (Germany, F.R.). Mineralogisches Inst.; Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). Jun 1986. 94p. (In German). Contract BMFT 03 E 6111 A. Order Number DE90732349. Available from NTIS (US Sales Only), PC A05/MF A01.

The reduction of high NaCl contents and the control of aqueous ferrous hydroxide complexes are the major problems in the utilization of highly saline thermal waters. It was established by experiments that, under the operation conditions of power generation plants, it is possible to bind NaCl in sodalite, $Na_8Cl_2Al_6Si_6O_{24}$ and thus to reduce the salt load of the brine by about 20%. Solutions of that kind are suitable for reinjection. Different solutions are proposed for controlling disturbances caused by aqueous iron complexes. (orig.) With 15 refs., 16 tabs., 32 figs.

7407 (GRSJ-8901, pp. 347-350) **Study for the use of low enthalpy geothermal water for district heating.** Matano, Yasuhiro (Taisei Corp., Tokyo (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170--: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

Low enthalpy geothermal water in Japan was deposited in generally new sedimentary basins (Tertiary and Quaternary). Such basins are found widely, in plains and mountain areas. In particular, many low enthalpy geothermal water resources are in Northern Japan, where the winter climate is very cold. Therefore, the said low enthalpy geothermal water resources are anticipated to be attractive sources of energy, though, so far, they have not been utilized much. The said resources generally exist in layers at over 1000m depth. To use these resources, it is required to drill geothermal wells, of which the depth may be between 1000m to 2000m, and the drilling costs are estimated at several tens of millions of yen to 2 hundred million yen. Therefore, the district heating will have to be on a large scale so as to utilize an effective system and with a stable heat demand over the long term, because in the case of smaller scale system an economical system will be unobtainable. Five case studies were carried out for low enthalpy geothermal district heating systems regarding the Sapporo City area in Hokkaido. 3 figs., 2 tabs.

7408 (GRSJ-8901, pp. 355-358) **Installed thermal capacity and thermal energy used of direct used of geothermal energy in Japan.** Sekioka, Mitsuru (National Defense Academy, Kanagawa (Japan)). Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170--: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The aim of this summary is to analyze the status of direct uses of geothermal energy in Japan for space heating of houses and green houses, domestic hot water supply, fish breeding farm heating and snow melting, by combining the inlet temperature and the flow rate of each installation. In Japan, geothermal energy is directly used in a number of sites not only in Hokkaido and Tohoku, both the cold regions where demand for heat is strong, but also in Kyushu, the mild region but blessed with thermal springs, for such purposes as elevation of agri- and aqua-cultural productivity as well as value-added of the products by heating. In order to provide further information of each direct use application in Japan, statistical analysis has been carried out in succession to the report of 1986. The total installed thermal power of 165 MWt and the total thermal energy used of 100MWt are estimated. They result in the average load factor of 60%. The rate of oil saved by geothermal direct uses is also evaluated 0.04%. 5 figs., 2 tabs.

1520 Geothermal Data and Theory

Refer also to citation(s) 7238, 7241, 7247, 7257, 7265, 7271, 7277, 7281, 7293, 7319, 7325, 7335, 7337, 7345, 7347, 7351, 7392, 7404, 7405

7409 (GRSJ–8901, pp. 51-54) **Numerical models of boiling and mixing in geothermal waters.** Reed, M.H. (Univ. of Oregon, Eugene (USA)); Spycher, N.F.; Akaku, K. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

In the first, this paper describes the results of numerical boiling of reconstructed fluid from Fushime well SCG-1 and the variances of mineral precipitations with decrease of temperature from 300°C, pH and total molality of metal species and molarity of aqueous complexes of Cu, Zn and Pb. They concluded that the calculated bulk composition and phase assemblage of mineral precipitates closely resembles those found in the Fushime wells. Next, they report the results of numerical mixing of partly boils (275°C) Fushime SCG-1 water and 100°C sea water and the variances of temperature of mixture with addition of sea water, composition of gas phase, mineral precipitates and pH and total molality of metal components. The results of the above mixing simulation between reconstructed geothermal water and sea water are conformable to the anhydrite-sulfide mineral assemblage observed in SCG-1 and can be applied. 7 refs., 2 figs.

17 WIND ENERGY

7410 (CANWEA–88-06463) **2nd National conference of the Canadian Wind Energy Association (CANWEA).** Lacey, V. (ed.). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. 469p. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

A conference was held to review developments in wind energy, primarily in Canada. Papers were presented in the areas of wind energy economics and commercialization, wind turbine theory and analysis, mechanical and pumping applications, power conversion systems, wind test site activities and research programs, wind/diesel hybrid systems, wind turbine testing, Darrieus rotors, aerodynamics, and wind energy standards. Separate abstracts have been prepared for 33 papers from this conference.

7411 (CANWEA–88-06463, pp. 249-252) **Initial data from a survey of wind turbines installed in Canada.** Hoffman, D. (World Wind Communications Co., Ottawa, ON (Canada)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

A survey of all wind turbines erected in Canada since 1970 is being conducted. The survey will document the number, type, generating capacity, and operational history of each turbine. Data from the survey are expected to be useful to the wind power industry in the areas of marketing and field service, and useful to the wind turbine owners in the areas of awareness of other owners and improving system reliability and performance, since a national survey of wind turbines has never before been conducted in Canada and nor have regional surveys been published. A literature search has revealed a total number of 185 wind turbines installed in Canada since 1970, with generating capacity totalling 663 kilowatts. Wind turbines built for the National Research Council or installed at the Atlantic Wind Test Site are not included in the survey. 3 tabs.

7412 (CANWEA–88-06463, pp. 229-247) **Atlantic wind test site activities.** Brothers, C. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

The Atlantic Wind Test Site (AWTS) is located at the extreme northern tip of Prince Edward Island. It consists of 185 acres of flat terrain bordered by a low cliff and exposed through 300 degrees to the Gulf of St. Lawrence. The AWTS was established in 1981 to provide Canada with a facility to test and to aid in the development of wind related technology for Canadian application. This paper describes the site facilities and current and recent projects, and discusses future activities and directions for the site. 3 refs., 6 figs.

7413 (CANWEA–88-06463, pp. 445-448) **AEI-USDA wind energy programs, 1985-1986.** Nelson, V. (West Texas State Univ., TX (USA)); Clark, R.N. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

A cooperative research program has been in progress since 1976 between the Alternative Energy Institute (West Texas State University) and the US Department of Agriculture's Conservation and Production Laboratory. An outline is presented of these programs which include: evaluation of wind turbines for pumping irrigation water; a 500 kW vertical axis turbine test program; data collection on wind characteristics in Texas and New Mexico; a wind test center; and education/information programs. 10 refs.

7414 (CANWEA–88-06463, pp. 435-443) **The Canadian wind energy R, D&D program.** Carpentier, M. (Energy, Mines and Resources, Ottawa, ON (Canada)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

The Canadian wind energy research and development program in the department of Energy, Mines and Resources (EMR) concentrates on six basic areas of interest: fundamental research, technology development, hybrid wind/diesel systems, evaluation and monitoring, wind parks, and technology transfer. Twenty-two research contracts are currently in force, for which EMR's contribution totals $1,091,500. Next year's priorities have been assigned in the following order of financial support: grid-connected wind energy conversion systems, wind/diesel systems, standalone systems, and water pumping. Other events of the year include the assigning of the rights and obligations of the Atlantic Wind Test Site in Prince Edward Island to EMR, and provision of a small tax concession in the February 1986 budget relating to capital cost allowances for wind energy systems. Some demonstration programs carried out by EMR's Renewable Energy Branch are also described, notably wind/diesel systems in remote communities.

1701 Resources and Availability (Climatology)

Refer also to citation(s) 7426

7415 (CANWEA–88-06463, pp. 267-278) **Wind-tunnel modelling of atmospheric boundary-layer flow over an isolated hill.** Shokr, M. (Atmospheric Environment Service, Toronto, ON (Canada)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC

Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

Determining the best site for location of Wind Energy Conversion Systems (WECS) requires accurate information about atmospheric boundary-layer flow over different terrain features. Canada's Atmospheric Environment Service (AES), along with six institutes from five different countries, was involved in a wind-energy related experiment designed to examine the effect of hills on wind flow. The site under study was an elliptical, isolated hill located in Scotland. Wind-tunnel simulation of neutrally-stable atmospheric flow over the hill was carried out at a model scale 1:1200 in the AES boundary-layer wind tunnel. The results provide information about the location and the extent of the steady accelerated flow regions, which constitute areas of preferred WECS sites, and also about high turbulence flow regions that should be avoided as candidate WECS sites. The study also elaborates on the sensitivity of the mean flow and turbulence characteristics to the prevailing wind direction of the mean flow. 6 refs., 8 tabs.

7416 (CANWEA–88-06463, pp. 253-266) **MS-Micro: a microcomputer version of a three-dimensional wind flow model for use in complex terrain.** Salmon, J.R. (Environment Canada, Downsview, ON (Canada)); Morris, R.J. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

MS-MICRO is a microcomputer implementation of the MS3DJH/3R numerical model for computing wind flow over complex terrain. The version described here is a direct descendent of the mainframe model, although it has been modified substantially to operate efficiently in the microcomputer environment. Also, several routines for pre-processing model input data and post-processing model output have been written or re-written to make this version function in a unified suite of programs from digitization of topographic contours and roughness boundaries through to plotting of normalized wind speed contour maps. This paper contains descriptions of theoretical and numerical modelling background material, the hardware required for the system, and the software. Finally, sample contour plots of system output are presented. 12 refs., 6 tabs.

7417 (TAU–CE-01344) **The availability of wind resources to meet Alberta's electric demand.** Baker, D.R. (DRB Engineering Consultants Ltd.). TransAlta Utilities Corp., Calgary, AB (Canada). Apr 1987. 55p. (CE–02845). Available from PC TransAlta Utilities Corporation, 110-12th Ave. SW, PO Box 1900, Calgary, AB, CAN T2P 2M1; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

This report studies the potential of Alberta's wind resources to contribute to the provincial electric demand. Software was developed to simulate the operation of a typical commercially available wind turbine (the Nordtank NTK 65/13S). The turbine's operation was simulated using 16 years of hourly wind speed records collected by the Atmospheric Environment Service from 10 sites in Alberta. It was found that only those sites located south of Calgary were able to achieve capacity factors above 0.10. The exception to this was Coronation which achieved an average capacity factor of 0.17. The three highest wind potential were sights analysed: Pincher Creek, Suffield, Manyberries. It was found that the group's average nonoperating time was reduced from 24.1% to 3.3%. Also, this grouping resulted in much less variation of its net capacity factor than when each site was studied individually. Further distribution of the turbines resulted in a 36% drop in the average net capacity factor (from 0.25 to 0.16). The strongest correlation between the electric demand and the performance of the turbines was found during the summer season. However, during the winter season, the turbines' performance decreased as the electric demand increased above 0.80 of the season's peak. 6 refs., 25 figs., 11 tabs.

1703 Legislation and Regulations

7418 (CANWEA–88-06463, pp. 415-424) **Evaluation of CSA [Canadian Standards Association] performance standards.** Brothers, C. (Canadian Standards Association (Canada)); Baker, D. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

A summary is presented of tests conducted at the Atlantic Wind Test Site (AWTS) and the Lethbridge (Alberta) Water Pumping Test Site (LWPTS) in order to evaluate the Canadian Standards Association's performance standards for wind energy conversion systems. The tests conducted at the AWTS were related to grid-connected wind turbines and to battery charging. Results indicated that the standards were practicable although there were some concerns raised: the vertical axis turbine used in the tests had difficulty in meeting the minimum data base requirements on a consistent basis, and it was not known whether this difficulty stemmed from the standard, the machine, or the topography. In addition, the battery charging tests encountered a similar problem; other problems relating to validity of data were also noticed. The tests conducted at LWPTS related to water pumping, and findings again indicate that, although the standard is workable, data base requirements were difficult to meet, particularly near cut-in and cut-out windspeeds. In view of these problems, alterations to the standard were proposed, and the minimum data base requirements were altered to compensate for the problems of low and high output conditions. Future requirements for wind turbine tests are considered. 4 refs.

7419 (CANWEA–88-06463, pp. 409-414) **CSA [Canadian Standard Association] Standards Program on wind energy.** Weir, B. (Canadian Standards Association (Canada)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

Standards are being developed by the Canadian Standards Association in the following areas related to wind turbines. The current status of these standards is described. Two standards have been published during the past year, bringing the total number of published preliminary standards to three. These are: F416, relating to safety; F417, relating to performance (including electrical generation, battery charging, and water pumping); and F418, covering the connection of a wind energy conversion system to a utility.

1704 Economic, Industrial, and Business Aspects

Refer also to citation(s) 7764

7420 (CANWEA–88-06463, pp. 51-63) **The politics of commercialization.** Passmore, J. (Passmore Associates International, Ottawa, ON (Canada)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

A discussion is presented on the commercial development of wind power in Canada, where the biggest single commercial market is in interconnection with utility grids. The obstacles to this type of commercialization are seen as being political. A number of small

wind power producers have tried to interconnect and have not been satisfied with the utilities' perceived lack of interest, their policies, and/or their buyback rates. A legitimate and politically supportable private-power position is suggested. Elements of this position include: the impropriety of the utility monopoly on electric power generation; the idea that the buyback price should be based on the incremental or marginal cost of a utility's newest and/or planned central generation facility; that private producers should be paid for capacity in the short term whether or not the system needs additional generation at the present time; and that private producers should be permitted to wheel power from one jurisdiction to another. The utilities are recommended to redirect their policies away from the engineering aspects toward the financial. The political advantages of promoting wind power are also mentioned.

7421 (CANWEA–88-06463, pp. 47-50) **Commercial wind energy activity in the United States.** Gray, T. (American Wind Energy Association). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

Continued, albeit slowing, growth is seen in wind energy development in the USA. A total of 1.5 billion kWh is estimated to be produced in 1986, and a trend is also noted for improvements in capacity factors and productivity per kW of installed capacity. Problems foreseen include long term financing, low oil prices, bankruptcy among some leading wind machine manufacturers, opposition by utilities to third party generation, concentration of the industry in California, and budget reductions in the federal wind energy program. The future is expected to include continued development of California wind farms, new niche markets for wind energy in other states, and development of a global market. The relevance of USA experience to the Canadian situation is discussed.

7422 (CANWEA–88-06463, pp. 37-45) **Wind and electric utilities: a view from Ontario.** Shalaby, A. (Ontario Hydro (Canada)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

A review of the potential for wind power use in Ontario shows that, due to the low wind speeds typically found over the province, wind power is not a competitive option for the province's interconnected power system. The evaluation of wind power electricity generation is discussed from the provincial utility's point of view; its policies regarding independent power generation are outlined and the future prospects for wind power are noted. The most likely application for wind generated electricity in Ontario is at diesel-wind hybrids in remote communities.

7423 (CANWEA–88-06463, pp. 19-35) **Non-conventional financing of Canadian wind parks.** Shepherd, J.C. (Blaney, McMurtry & Partners (Canada)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

Nonconventional techniques for financing wind parks in Canada use tax benefits and government incentives to reduce installed costs. Discussion is focused on two main issues: converting tax benefits into cash, and offering the government sufficient socioeconomic tradeoffs necessary to obtain assistance. An examination of the variables affecting wind park economic viability shows that power buyback rates and installed cost per kW are the major concerns. In the area of tax-assisted financing, scientific research tax benefits are becoming less useful, both because the technology is well developed and the criteria for a project's qualifying as research are rather ill-defined. The capital cost allowance has recently been revised to include wind power installations, and offers some benefits with respect to tax deferral. Investment tax credits have a restriction which prevents their availability when the purpose of the investment is producing power for sale. New tax rules, related to tax shelters and partnerships, have added significant risk to public financing of wind parks. In the case of user financing, it may be possible to use the production note structure in which a phantom utility is, in effect, created to sell power to the generating facility's real owner. In the area of government assistance, the trend is toward job creation in disadvantaged areas as the most important criterion for such assistance. Wind parks are capital rather than labor intensive, and thus are not as saleable unless sufficient political or social benefit can be proposed. Some details are given for the Cape Breton grants program, the Atlantic Enterprise program, and other relevant federal and provincial programs.

7424 (CANWEA–88-06463, pp. 5-18) **The commercial marketplace in Alberta.** Johnson, D. (Wind Power, Inc (Canada)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

This discussion of wind power in Alberta outlines the activities of the Small Power Producers Association of Alberta, the place of wind power in relation to the policies of the provincial government and electric utilities, and the economic factors influencing installation of small wind power plants. Mention is made of some of the wind power installations that have been recently put into operation. It is noted that there are uncertain policies and prices in place to accomodate small wind power producers, and it is felt that the market will be driven more and more by activity in the commercial and industrial sectors. An appendix includes a reprint of a pioneering decision before the Alberta Energy Resources Conservation Board regarding interconnection of a privately operated wind-powered electric generator to the TransAlta Utilities system.

7425 (CANWEA–88-06463, pp. 7) **Optimization in wind turbines.** Ereaux, J. (Adecon Energy Systmes, Inc.). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

This paper briefly describes primary design variables such as weight and rotor geometry. It is possible to show that the optimization of a wind turbine is simply the process of maximising the benefit to cost ratio. The primary benefit produced by the wind turbine is the energy production, and if we ignore the effect the quality of the power has on the value, we can assume that the benefit of the turbine is proportioned to the energy production. Thus, the optimization process becomes one of maximising the energy production to cost ratio.

7426 (CANWEA–88-06463, pp. 329-366) **Wind/diesel potential for remote power systems: technico-economic aspects.** Reid, R. (Hydro-Quebec, Varennes, PQ (Canada)); Saulnier, B. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, ,

CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

Wind turbines are expected to find their first economically viable application in remote communities, where electricity costs and wind regime are high. A review of present wind/diesel technology indicates that a no-storage high-penetration scheme appears technically and economically feasible while maintaining an acceptable quality of supply. An economic analysis of the potential of wind energy has shown that, with the present control scenario and forecast fuel prices, an average wind speed of 6.8 m/s and an optimum (100%) penetration, some 9 MW of wind turbines could be profitably installed in Northern Quebec villages for a net present value of around $8,000,000. 24 refs., 16 figs., 6 tabs.

7427 (CANWEA–88-06463, pp. 425-434) **Wind power in Alberta, twenty-one months after the decision.** Miller, H.D. (TransAlta Utilities (Canada)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

On June 8, 1984, the Alberta Energy Resources Conservation Board (AERCB) issued its Decision D 84-12 regarding a wind-powered electric generator near Pincher Creek. In part of that Decision, the AERCB requested TransAlta Utilities collect information on the Small Power Producer (SPP) wind generators interconnected with its electric system. Specifically, TransAlta was to collect information, assisted by SPPs on the system, on the operation of the SPP facilities, and on their interaction with TransAlta's electric system and with the Alberta Interconnected System. This paper provides a detailed account of the results of the data collection during the first twenty-one months of operation from January 1985 to September 1986. 6 figs., 2 tabs.

7428 (ENEA-RT-FARE–86-2) **Integrated eolian-diesel systems: technology assessment and economics.** Arena, A.; Cerreta, R. ENEA, Casaccia (Italy). Dipt. Fonti Alternative e Risparmio Energetico. May 1986. 149p. (In Italian). Order Number DE89761928. Available from NTIS (US Sales Only), PC A07/MF A01.

The necessity of developing integrated eolian-diesel systems stems from the presence of a large number of isolated users who must bear high costs of fuel transportation or costly connection to the public utility's power distribution network. In this report, wind energy and its applications as a renewable energy source is presented in two parts. The first part examines the problematics of commonly used installations excluding storage systems. The main technological solutions adopted are evidenced along with a program for dynamic analysis. The second deals with problems relative to storage systems. Finally, the principal criteria for economic evaluations of eolian-diesel systems are defined.

1705 Environmental Aspects

7429 (NEI-DK–232) **Consequences for birdlife of installation of smaller wind turbines.** Ornis Consult APS, Copenhagen (Denmark). Jun 1989. 84p. (In Danish). Contract TR-87.605. Order Number DE90728079. Available from NTIS (US Sales Only), PC A05/MF A01.

Wind turbine arrays are often placed in open coastal areas which may well be important breeding of gathering localities for a number of bird species. Nine windmill parks (55-99kW) in Denmark have been observed for a period of 15-18 hours (for each park). Local birds appear to habituate to the windmills, and migrating wildfowl, especially swans and geese often change their course at a long distance from the sites. Waders, however do not react until they come close and often react violently, yet only two birds, out of 1939 passing flocks, have been recorded as killed during the period of observation. It was concluded that if windmills are placed in a line at small intervals across a migration route they may present a serious problem to wildfowl and cormorants, for example. The problem is greater where wind turbine arrays have been placed at locations being used as feeding grounds by the birds. It was observed that some species had restricted their feeding areas. It is concluded that windmills present a minor threat to migrating birds compared to radio towers. It is recommended that migration routes and gathering areas of sensitive species, primarily wildfowl and waders, should be avoided as sites for wind turbine arrays. The development of standardized guidelines is advised. (AB) 21 refs.

7430 (STEV-VIND–89-15) **Noise from wind power plants with variable speed vs background noise.** Ekstroem, L. (Aeronautical Research Inst. of Sweden, Bromma (SE)). Statens Energiverk, Stockholm (Sweden); Aeronautical Research Inst. of Sweden, Bromma (Sweden). Nov 1988. 42p. (In Swedish). Project STEV-506-266. (FFAP-A–779). Order Number DE90728281. Available from NTIS (US Sales Only), PC A03/MF A01.

The noise level is estimated as a function of measured wind velocity and control technological data for the wind power plants. Also the background level emanating from rustling leaves etc. was estimated. The result is presented in terms of time signals, cumulative distribution and the total time interval during which the sound level exceeds background for 1, 2 and 5 seconds respectively.

1706 Wind Energy Engineering

Refer also to citation(s) 7181, 7427, 7634

7431 (CANWEA–88-06463, pp. 83-106) **Dynamic-stall models for Darrieus rotors.** Paraschivoiu, I. (Ecole Politechnique de Montreal, PQ (Canada)); Allet, A. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

Comparisons have been made between aerodynamic performance predictions using two dynamic-stall methods and experimental data for 17-M Sandia wind turbine. These dynamic-stall models are the incidence delay methods orginating from Boeing-Vertol and from the Massachusett Institute of Technology (MIT). In comparisons of prediction against independent data sets, the Boeing-Vertol method consistently underpredicts the peak lift and pitching moment coefficients, while the MIT method appears to over-emphasize the importance of vortex shedding on pitching moment. The MIT model calculations show that aerodynamic coefficients are underestimated in comparison with those of Gormont model, even if the shape of curves is quite the same. The MIT model provides a good prediction of the dynamic-stall regime. This is characterized by a plateau oscillating near the experimental data of the rotor power vs wind speed at the equator. 14 refs., 10 figs.

7432 (CANWEA–88-06463, pp. 65-82) **Modal analysis of the 50 kW IREQ wind turbine.** Pastorel, H. (Inst. de recherche d'Hydro-Quebec, Varennes, PQ (Canada)); Heilmann, W.; Saulnier, B.; Leonard, F. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

A theoretical and experimental study of the properties of a vertical axis wind turbine is described. This study had the objective of verifying the accuracy of a finite element model of a vertical axis turbine, and to test two modal analysis programs intended for the experimental study of large flexible structures. Results of the analysis have been obtained for the 50-kW Darrieus turbine developed

by the Hydro-Quebec Research Institute. The dynamic characteristics of the turbine were calculated by two methods: Ritz's generalized dynamic reduction method, and static condensation or Guyan reduction. After many trials, the two methods have led to identical results for the first 18 vibrational modes. To verify the model, a total of 18 accelerometers were installed on the turbine rotor and data were obtained at a sampling rate of 200-300 points per second. Four types of excitation of the rotor were used, based on four basic families of modes. Generally, a good agreement between theoretical and experimental results was obtained for the first 10 modes. The higher modes were not able to be verified experimentally due to a lack of accelerometers on the rotor and the difficulty of moving the existing ones to other measuring points. The torsion modes were identified with less precision in the model because of modelling difficulties related to the complexity of the shaft in the rotor base. 5 refs., 8 figs., 2 tabs.

7433 (CANWEA–88-06463, pp. 175-187) **A twin-airfoil type, oscillating beam, wind-driven water pumper.** Kentfield, J.A.C. (Univ. of Calgary, Calgary, AB (Canada)); Booth, M.; Horsley, D. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

Results are presented of wind-tunnel tests carried out on a fully functional, load-pump equipped, working model of a twin-airfoil oscillating beam water pumper. The test results indicate that the machine works well and that the upwind aerodynamic surface, or canard, serves to inhibit stalling in weak winds. A full-scale prototype machine was also constructed. It was found that the projected improved full-scale performance, whilst inferior to that of more conventional rotary type wind driven water pumpers of comparable size, appears to be adequate for a number of applications. The inherent advantages of oscillating beam water pumpers are perceived to be: simplicity, ease of maintenance, a low projected first cost, and low frequency operation which permits these devices to be directly coupled, without an intermediate speed reducer, to reciprocating deep-well pumps. 4 refs., 17 figs.

7434 (CANWEA–88-06463, pp. 159-173) **Optimization of wind pumping reservoir capacity.** Schiller, E.J. (Univ. of Ottawa, Ottawa, ON (Canada)); Assam, U.D. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

The derivation of a computer program to determine the optimum size of a storage reservoir for a wind-powered water pumping system is described. The program is for a multi-bladed horizontal axis windmill connected to a reciprocating pump. The program can use either measured wind characteristics or statistical wind distributions (Weibull or Rayleigh). The inputs are wind turbine, wind pump and well characteristics, and user demand levels. The output is presented as storage-yield curves as a function of different reliability levels. 7 refs., 4 figs., 1 tab.

7435 (CANWEA–88-06463, pp. 135-157) **New developments in Canada in wind powered water pumping.** Edworthy, J. (Nor'wester Energy Systems Ltd., Calgary, AB (Canada)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

In the past five years the topic of remote water pumping has become an important one in western Canada, due to severe and continuing drought conditions, which were only slightly mollified in 1986. It was farsighted and timely that the Lethbridge Wind Turbine Test Facility, intended primarily for alternate energy water pump testing, was set into operation during this period. This short paper presents an overview of other papers presented at the same conference. 16 figs.

7436 (CANWEA–88-06463, pp. 107-122) **A wake model for Darrieus rotors and its application to the calculation of nonstationary forces.** Masse B. (Institut de recherche d'Hydro-Quebec, Varennes, PQ (Canada)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

A new two-dimensional wake model is presented for the calculation of velocities induced by the wake of a Darrieus turbine in the nonstationary regime. The model is intended to complete a calculation model proposed by Masse (1986) for aerodynamic forces, and also to permit the inclusion of stochastic wind effects (turbulence) and variations in turbine rotation. The model's approach is described in detail, and results are compared to those obtained with a previous turbulence model proposed by Strickland (1980). It is noted that, in general, the wake is well represented, especially near the rotor. Since the proposed model neglects the influences of turbulences upon one another inside the wake, the form obtained differs somewhat than that calculated by the Strickland model. This loss of precision at the geometric level permits a very rapid computer calculation and, since the wake near the rotor is sufficiently well represented, the precision obtained allows the belief that the effect of the wake will be calculated with an acceptable precision. Comparison of the two models in their calculation of both the angle of attack and the relative velocity also indicates that the proposed model is sufficiently precise. The model is thus verified for the regime in which the windspeed and the rotor rotational speed are constant. The proposed model was then extended for calculation of nonstationary conditions. A rotor startup was simulated, and it is noted that the turbine is totally started after 5 revolutions, but the wake needs a few additional revolutions before stabilizing and attaining a permanent state. This behavior was predicted and thus the proposed model seems to represent the phenomena well. 6 refs., 7 figs.

7437 (CANWEA–88-06463, pp. 189-201) **Performance testing of the Deltx WP-20.** Baker, D. (DRB Engineering Consultants Ltd., Calgary, AB (Canada)); Paterson, B.A. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

In 1985, a proposal was submitted to the National Research Council requesting funds to evaluate the Deltx WP-20 wind pump at the Lethbridge Wind Research Site. The WP-20 is manufactured in Calgary by the Deltx Windpump Corporation for use in the irrigation, drainage, and municipal water supply areas. The results of the performance testing were mixed. Pumping performance of the machine exceeded expectations by a wide margin but this was offset by numerous mechanical problems. Due to these problems, data gathering operations at the test site were unable to obtain a complete performance curve of this unit. Both optimistic and pessimistic extrapolations of the curve indicated that the performance of the WP-10 relative to its swept area was much better than any water pumper tested on the site to date. In Lethbridge it was estimated that it would pump between 131,000 and 180,000 m^3/annum (at six

metres lift). With a swept area of 19.6 m^2, this translates to between 6700 and 9200 m^3 per square metre of swept area. Its nearest competitor, the Wind Baron, was calculated to have the potential of pumping 4500 m^3 per square metre of swept area. 8 figs., 3 tabs.

7438 (CANWEA–88-06463, pp. 123-133) **Design of gearless wind turbine varriable speed generators.** Hylander, J. (Ecole Politechnique de Montreal, PQ (Canada)); Zweygbergk, S. van; Engstram, S. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

If the use of gear boxes in grid connected wind turbines could be eliminated with convertor connected low speed generators, a reduction of cost and weight of the plant could be possible. Studies of these generators have been performed within the Swedish wind energy research program. Earlier designs of gearless low speed generators have often had fixed speed operation with the stator connected directly to the grid. However, if the generator is connected to a convertor in order to allow variable speed operation, it will be possible to use frequencies higher than the grid frequency. With higher frequency, the magnetic flux in the generator will be reduced, which makes it possible to design the machine with less iron. This will reduce the weight and cost of the generators. The design results from this study of low speed synchronous and induction generators in the rated range of 200-4000 kW are presented in this paper together with comparative designs of standard machines. 4 refs., 4 figs.

7439 (CANWEA–88-06463, pp. 279-288) **Hybrid wind turbine-diesel power supply for a radio transmitter.** Arsenault, J.-M. (Groupe-Conseil Thermeca, Quebec, PQ (Canada)); Joliceur, Y.J.C.; Turgeon, G. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

A radio transmitter was installed on a 2500-foot-high mountaintop in Quebec. In view of the high costs for connecting the site with the utility grid, it was decided to power the transmitter by a wind-diesel hybrid system. Such a system was chosen for reasons including competitive investment costs, low operating costs, feasibility, and the possibility of subsidies. The system consists of an Extrawatt horizontal axis turbine with a 6.5 m diameter rotor, a 2-cylinder 9.5 kW diesel engine, a 6 kW alternator, and associated control systems. The performance of the system was estimated from data found in reports concerning systems of similar design. With an average windspeed of 7 m/s, energy production by the turbine is calculated at 27,500 kWh. Taking into account the efficiency of the various components of the system, the resulting electric energy will be 13,750 kWh. Since the estimated power consumption of the transmitter site is 30,000 kWh, the diesel is required to supply the remaining 16,250 kWh. Therefore, use of the wind turbine allows the saving of about 46% in fuel costs over a diesel-only installation. 2 refs., 2 figs., 1 tab.

7440 (CANWEA–88-06463, pp. 203-207) **Flow visualization for an oscillating profile in a similar motion with the Darrieus turbine.** Desy, P. (Ecole Polytechnique de Montreal, Montreal, PQ (Canada)); Paraschivoiu, I.; Fraunie, P.; Beguier, C. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

The purpose of this work is to visualize the flow in the dynamic-stall conditions for an oscillating profile in a water tunnel. The oscillating blade used in the experiments is a NACA 0018 profile that has a similar motion to a Darrieus wind turbine blade. In rotation, the angle between the chord and the undisturbed steam flow direction is always the same. That is the way that the kinematic conditions of the Darrieus rotor were simulated. The rotating blade has a plunging and pitching motion. Pictures taken at about every 5^0 in the rotational circle show the dynamic-stall phenomenon. The dynamic stall is observed at low tip-speed ratios. Pictures from a movie film show all details of the stall phenomenon for different tip-speed ratios. 12 refs., 21 figs.

7441 (CANWEA–88-06463, pp. 381-389) **A wind tunnel investigation of aerobrakes for vertical axis wind turbines.** Penna, P.J. (National Research Council of Canada, Ottawa, ON (Canada)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

Aerobrakes of a simple design, consisting of rectangular plates hinged at the trailing edges of the blades, have often been incorporated into the control systems of Canadian vertical axis wind turbines for overspeed protection. However, this design loses some of its effectiveness at low tip speed ratios when the blades experience high angles of attack and deep stalling. Therefore, other aerobrake configurations were investigated at the National Aeronautical Establishment with a view to obtaining greater effectiveness at high angles of attack. Flow visualization tests were carried out on two configurations and wind tunnel tests were carried out on three configurations. The most effective configuration was considered to be the one that maintained a negative thrust coefficient over the widest range of angle of attack. 1 ref., 7 figs.

7442 (CANWEA–88-06463, pp. 367-379) **Increased output from Darrieus rotors.** Malcolm, D.J. (Indal Technologies Inc., Mississauga, ON (Canada)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

The consequences of incorporating early-stall tailored airfoil blades on the Indal 6400 vertical axis wind turbine rotor are studied. The same (520 kW) power train is used while the energy capture is maximised for four different wind regimes. The results of a dynamic structural analysis of one of the rotors and the fatigue strength of typical connections suggest a limit to the size of rotor that uses a single-extrusion aluminum blade. The final decrease in cost of energy is conservatively estimated to range between 14 and 25%. 5 refs., 5 figs., 3 tabs.

7443 (CANWEA–88-06463, pp. 391-407) **Windfarm coupling to one diesel set.** Noel, J.-M. (Aerowatt-International, Bonneuil Cedex (France)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

The mastery of the operating stability of a wind/diesel hybrid system using Aerowatt-International variable pitch wind generators make it possible to have no limit on the wind energy component of such a system. This paper describes how Aerowatt-International's

wind generators can be directly coupled with a diesel-based generating station, and how they also permitting the installation of as much wind-based generating capacity as is deemed necessary and economically viable. 15 figs.

7444 (CANWEA–88-06463, pp. 313-328) **Project Eole update.** Beausoleil, G.H. (Lavalin, Inc.); Plante, J. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

Progress on a vertical axis turbine of the Darrieus type under construction in Cap-Chat, Quebec is reported. The turbine has five major subsystems: turbine rotor, rotor support system, and the mechanical, electrical, and instrumentation systems. These are briefly described, and the reason for selection of specific design options are given. As of October 1986, the civil works are complete; the main electrical equipment and mechanical drive train components have been installed and pre-commissioned; and the rotor tower and part of the rotor have been erected. Completion of all work prior to commissioning is scheduled for December 1986. 6 figs.

7445 (CANWEA–88-06463, pp. 309-312) **Fort Severn wind/diesel project. Update.** Drewes, P.; Hume, D. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

A remote Ontario community has been selected as the site of the province's first large-scale operational wind turbine. A Howden HWP60 machine was modified to withstand local conditions, the site was prepared, and the turbine was shipped to the site for installation. The turbine is intended to operate as part of a hybrid wind/diesel system. This report describes the progress to date; by October 1986 only the turbine blades remained to be installed, and the site was ready for interconnecting cabling.

7446 (CANWEA–88-06463, pp. 449-451) **Wind energy activities in Sweden.** Engstrom, S. (National Energy Administration (Sweden)). Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

The government-funded wind energy program in Sweden was initiated in 1975 and has been concentrated on the development and evaluation of two large wind energy conversion systems (WECS), Maglarp (3 MW) and Naesudden (2 MW). Following the evaluation of the program in late 1984 and the government energy bill in 1985, the Swedish utilities are forming a development company for wind energy that together with government funds will finance a medium scale WECS and design studies on multimegawatt WECS. Further evaluation of the Maglarp and Naesudden WECS will also be carried out together with other research activities in the government-funded 1984-87 wind energy research program. 3 refs.

7447 (ETDE-mf–0732504) **EOLE-D - MW-Darrieus wind energy technology. Concept study. Final report.** Henseler, H.J.; Fritzsche, A. Dornier-System G.m.b.H., Friedrichshafen (Germany, F.R.); Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). 1989. 102p. (In German). Contract BMFT 0.328933 A. Order Number DE90732504. Available from NTIS (US Sales Only), PC A06/MF A01.

In a feasibility study it was investigated to adapt the Canadian Darrieus technology of EOLE-C to German environmental and operational conditions. It was shown, that the MW VAWT system exhibits an interesting potential for Germany. With the wind conditions at the North Sea it is expected that the 2 MW plant will produce about 4-5 GWh per year. With the estimated manufacturing cost attractive cost of electricity may be expected. The technology of the Canadian plant may be adopted in principal, since mechanical and electrical systems function very well and long service life is expected. Good operational behaviour allows to omit aerobrakes. For cost reduction as gear box and a medium fast generator will be installed with EOLE-D. During the next phase the detailed adaptation of the system will be performed as a preparation of the installation of a German demonstration plant. (orig.) With 13 refs., 44 tabs.

7448 (FRNC-TH–3511) **Savonius wind turbines: mechanical and aerodynamical behaviours.** Aouachria, Z. Aix-Marseille-1 Univ., 13 - Marseille (France). 1987. 99p. (In French). Order Number DE90708160. Available from NTIS (US Sales Only), PC A05.

An experimental measuring method of the peripheral pressures on a Savonius type vertical axis rotor is presented. The results are then used in a computation model in order to determine the C_M and C_p mechanical parameters of the machine. The drag and lift coefficients and the vibrating behaviour of the rotor under aerodynamical forces are also determined. The blade pressure field is correlated with the vortex system produced by the rotating wind turbine. Pile-type suspension systems for the vibration isolation of a three-blade Savonius rotor are examined.

7449 (MBB-UE–0001-89-PUB) **Adaption development of wind energy converter MONOPTEROS 50.** Brauer, J.; Gildehaus, F.; Helms, L.; Mickeler, S.; Roeer, J.; Schweren, H.; Uecker-Weigel, M.; Wachsmuth, R.; Wieland, K. Messerschmitt-Boelkow-Blohm G.m.b.H., Delmenhorst (Germany, F.R.). Unternehmensbereich Energie- und Industrietechnik; Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). Apr 1989. 460p. (In German). Contract BMFT 03E8154A;BMFT 03E8154B;BMFT 03E8657A. Available from Copy held by UB/TIB Hannover.

The performed purpose for further development of the experimental plant MONOPTEROS 400 located in Bremerhaven contains essentially the development of the serial manufactured plant MONOPTEROS 50, based on the results and the experiences of the first big single blade wind energy converter and after the technical feasibility had already been proved. In accordance with this object in view the following working program had been performed: optimization of the rotor in regard to diameter and rated power, ascertainment of the rotor loads and the resulting structure weights resulting, revision of the control system concept with the targets: simple control elements, high outage safety, low load parking position, revision of the concept of blade manufacturing including the manufacturing devices, revision of the complete drive train, development of an extended tower without guys, production of the complete manufacturing drawings and lists, complete proof calculations in regard to static stresses/fatigue life, dynamic stability, safety analysis and performance of an experimental program with the demonstration plant M 400. (orig.) With 49 refs., 193 figs.

7450 (NEDO–8809, pp. 170-183) **Development of large-scale megawatt class wind turbine generating system. Development of elemental technology.** Chiba, Ryuji (Tohoku Electric Power Co., Inc., Sendai (Japan)). New Energy Development Organization, Tokyo (Japan). 16 Sep 1988. (In Japanese). In *Proceedings of Parallel Sessions for the 8th NEDO General Assembly.* Available from NTIS (US Sales Only), PC A23/MF A01.

Reports are made on the problems in technological development and the result of elemental technological development in connection with the Large-Scale Wind Turbine Generating System, a project commissioned by NEDO. The target of the project is to develop elemental technologies for a large-scale MW class wind turbine generating system which is connected to the existing electric systems, and to establish an economically competitive plant as compared with the existing power sources. A trial calculation of the generating cost revealed that 1,000kW class was economically the best for MW class power generation. A full-sized model was made in 1987. The blade and its control system, power transmission

mechanism, outline of the tower, analysis of the entire coupled vibration, and the outline of the elemental devices are introduced. A simulation, performed under the condition that an inductive generator is connected in parallel, indicated that there would be no specific problem. Development in other countries than Japan and related problems are tabulated. Hypothetical calculation gives the generation cost of approximately 14 Yen/kWh. 1 figure, 4 tables.

7451 (NEDOJ-P–8731) **Vision for the introduction of the wind power generation system. Survey on the prospective market (2).** Senda, Toshiaki; Nagata, Koichi; Nakazawa, Yasuharu; Miyachika, Hideto; Matsuda, Eiko. New Energy Development Organization, Tokyo (Japan). Mar 1988. 244p. (In Japanese). Order Number DE89910386. Available from NTIS (US Sales Only), PC A11/MF A01.

In this study, by selecting 50 points, having a potential of wind power generation from the viewpoint of wind conditions, out of the total AMeDAS point (838 sites) through the screening by annual average wind velocity; simulation analysis was made on the operating conditions of the power generation system in the case that a 100 kW class wind power generation plants were installed at the respective sites by utilizing WPES-AMeDAS. Based on the results, 15 prospective sites were selected and assessment as a plant location was made by the actual field observation. Then a comprehensive assessment was made by the analysis on the economical aspects of the wind power plant. Finally, as a result, practically prospective 14 sites were proposed. Major items of reports are as follows: 1. Selection of sites with prospective wind conditions. 2. Analysis and assessment of prospective sites. 3. Economic aspects of a wind power generation system. 52 figs., 9 tabs.

7452 (NEI-DK–222, pp. 4-13) **General formulation for aerodynamic analysis of wind turbine.** Arsuffi, G. (ENEA (IT)). Danmarks Tekniske Hoejskole, Lyngby (Denmark). Afdelingen for Fluid Mekanik; International Energy Agency, 75 - Paris (France). 1989. (CONF-8811284–: 2. symposium on aerodynamics of wind turbines, Lyngby (Denmark), 21-22 Nov 1988). In *Joint action on aerodynamics of wind turbines. Supplement.* Order Number DE90719250. Available from NTIS (US Sales Only), PC A03.

IEA R and D WECS.

The improvement of the fluid-turbine interaction description require further modelling work on the following areas: - 3-D flow wind turbine rotor, with particular attention to airfoil section stall condition; - rotor in yaw aerodynamics; - turbine interaction in wind farms; - acoustic emission; - "ad hoc" airfoil sections. In order to enhance the computational capability on these subjects our Laboratory has started a program to applicate more sophisticated methods to the aerodynamic analysis of wind turbine. Both the existing method adaptation and further development opportunities were considered. Our investigation led to choose a very interesting formulation due to Morino which is used at the present for helicopter rotor and propfan analysis. The main advantage of this formulation is its generality which allows to deal with all the mentioned wind turbine aerodynamic problem without changing the approach. In fact the formulation can be used to calculate compressible as incompressible, viscous as inviscid rotational flows by the same unified method, only incorporating some additional model which can be required to perform special analysis (as for instance turbulence or boundary layer moedl). A short description of this method is given here. (AB).

7453 (RISO-M–2768) **Aerodynamics of a full-scale, non rotating wind turbine blade under natural wind conditions.** Paulsen, U.S. Risoe National Lab., Roskilde (Denmark). May 1989. 85p. Order Number DE90728136. Available from NTIS (US Sales Only), PC A05/MF A01.

EFP.

Experiments on aerodynamic behavior are carried out under natural wind conditons on a full-scale NACA 44XX series airfoil blade, with a 6.4 m span and a linear variation of taper, thickness and geometrical twist. The blade is mounted vertically on a 12 m high tower on a moment balance, which mearsures bending moments in two directions perpendicular to each other. Bending moments are analysed in directions parallel and perpendicular to the onset flow and to the cord at the tipsection, and results are compared with different theoretical models using two-dimensional airfoil-section characteristics gathered from wind tunnel tests. The obtained chord Reynolds number ranges between 500,000 and 1,000,000, and the influence on the aerodynamic characteristics is discussed. The onset flow is measured 2 m in front of the blade, at a height of approx. 15.8 m above ground level. The comparison between the experimental and theoretical approaches show significant deviations on drag and lift effects for the blade considered. The main deviation between airfoil characteristics measured in natural wind and those obtained from wind tunnel measurements are found in the region where stall occurs. The particular measurements demonstrate at angles of attack after stall that more lift and less drag can be achieved than under wind tunnel test condition. The airfoil-characteristics are analysed through parameters describing variations governed by shifts in wind direction and wind speed, and through the blade bending motion. From these data, conclusions are made illustrating the relative importance of instationary effects originating from turbulence, hysteresis and three-dimensional flow around the blade. The findings are discussed relative to wind turbine application, considering a 55 kW rotor using a blade of the present type. (author) 6 taps., 33 ills., 11 refs.

7454 (SAND–89-1536C) **Performance predictions for an intermediate-sized VAWT based on performance of the 34-M VAWT test bed.** Dodd, H.M. (Sandia National Labs., Albuquerque, NM (USA)). Sandia National Labs., Albuquerque, NM (USA). [1989]. 17p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC04-76DP00789. (CONF-900136–4: 9. ASME wind energy symposium, New Orleans, LA (USA), 14-17 Jan 1990). Order Number DE90002835. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The DOE/Sandia 34-m Vertical Axis Wind Turbine (VAWT) Test Bed is a research turbine that has been in operation for over a year. With the advanced technology components incorporated in the turbine (including airfoils, structures and variable speed operation), its performance can be used to predict next generation commercial VAWT potential. This paper begins with the predicted and measured performance results obtained from the Test Bed and applies these results to a hypothetical commercial machine of the same size. The effects of a number of parameters are included in the performance analyses. First, the importance of siting considerations are presented, including wind frequency distributions (both real and Rayleigh) and mean wind speed and wind shear effects. Next, the paper shows the relative contribution of variable speed operation to improved performance and discusses other aspects of variable speed. The predicted performance of a 34-m VAWT is compared to existing machines, with annual energy capture per unit of swept area being the primary comparative metric. Finally, some cost of energy considerations associated with these technological advances are covered. 10 refs., 6 figs.

7455 (SAND–89-1795C) **Rainflow counting algorithm for the LIFE2 fatigue analysis code.** Schluter, L.L. (Sandia National Labs., Albuquerque, NM (USA)); Sutherland, H.J. Sandia National Labs., Albuquerque, NM (USA). 1989. 3p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC04-76DP00789. (CONF-900136–3: 9. ASME wind energy symposium, New Orleans, LA (USA), 14-17 Jan 1990). Order Number DE90002834. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The LIFE2 computer code is a fatigue/fracture analysis code that is specialized to the analysis of wind turbine components. The numerical formulation of the code uses a series of cycle count matrices to describe the cyclic stress states imposed upon the turbine. In this formulation, each stress cycle is counted or "binsed" according to the magnitude of its mean stress and alternating stress components and by the operating condition of the turbine. This paper describes a set of numerical algorithms that have been incorporated into the LIFE2 code. These algorithms determine the cycle count matrices for a turbine component using stress-time histories of the imposed stress states. Example problems are used to illustrate the use of these algorithms. 4 refs., 4 figs.

7456 (SAND–89-2476C) **Structural response measurements and predictions for the SANDIA 34-Meter Test Bed.** Ashwill, T.D. (Sandia National Labs., Albuquerque, NM (USA)); Veers, P.S. Sandia National Labs., Albuquerque, NM (USA). 1989. 8p. Sponsored by U.S. DOE Conservation & Renewable Energy.

DOE Contract AC04-76DP00789. (CONF-900136–1: 9. ASME wind energy symposium, New Orleans, LA (USA), 14-17 Jan 1990). Order Number DE90002575. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Measurements of structural response during operation of the 34-Meter Test Bed vertical axis wind turbine are compared with analytical predictions. Measured structural data include stationary and rotating modal frequencies, cable natural frequencies, and operating stresses. These data are compared to analytical results obtained with the use of NASTRAN-based structural codes. In the case of operating stresses, analytical results with and without turbulence are compared to measured stresses. Data taken during two significant events, a high wind over-speed condition with an emergency stop and a cable resonance that couples with a tower natural frequency, are shown. 11 refs., 19 figs.

7457 (SAND–89-2597C) **Aerodynamic design and initial performance measurements for the SANDIA 34-metre diameter vertical-axis wind turbine.** Berg, D.E. (Sandia National Labs., Albuquerque, NM (USA)); Klimas, P.C.; Stephenson, W.A. Sandia National Labs., Albuquerque, NM (USA). 1989. 7p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC04-76DP00789. (CONF-900136–2: 9. ASME wind energy symposium, New Orleans, LA (USA), 14-17 Jan 1990). Order Number DE90002574. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The DOE/Sandia 34-m diameter Vertical-Axis Wind turbine (VAWT) utilizes a step-tapered, multiple-airfoil section blade. One of the airfoil sections is a natural laminar flow profile, the SAND 0018/50, designed specifically for use on VAWTs. The turbine has now been fully operational for more than a year, and extensive turbine aerodynamic performance data have been obtained. This paper reviews the design and fabrication of the rotor blade, with emphasis on the SAND 0018/50 airfoil, and compares the performance measurements to date with the performance predictions. Possible sources of the discrepancies between measured and predicted performance are identified, and plans for additional aerodynamic testing on the turbine are briefly discussed. 12 refs., 10 figs.

7458 (SAND–89-7037) **Fatigue behavior of vertical axis wind turbine airfoils with two weld configurations.** Mitchell, M.R. (Rockwell International Corp., Thousand Oaks, CA (USA). Science Center); Murphy, A.R. Sandia National Labs., Albuquerque, NM (USA); Rockwell International Corp., Thousand Oaks, CA (USA). Science Center. Oct 1989. 37p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC04-76DP00789. Order Number DE90002628. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Sandia National Laboratories contracted with Rockwell International Science Center to perform a series of narrowband, pseudo-random cyclic fatigue tests on sections of 6063-T651 aluminum, Darrius-type, vertical axis wind turbine (VAWT) airfoils. We designed and constructed a load member that was mounted within the frame of a rigid 200-kip servohydraulic, closed-loop test system to hold the VAWT section and permit cantilever bending along the shear centerline of the beam. A computer program was developed to synthesize a narrow band, pseudo-random load history with fixed root mean square (RMS) stress levels at a given bandwidth and central frequency. Six specimens each of two different weld configurations at the flange mounting plate were tested at several RMS stress levels with failure defined as visual observation of a 3-inch-long crack in the VAWT. In order to test at as great a frequency as possible, a 20-kip hydraulic ram with a 10-GPM servovalve was employed with a 20-GPM pump. Tests were performed from 2 to 1.3 ksi RMS on the two-weld configurations. The conclusions are obvious that the fillet-weld design is far superior to the butt-weld design in the range of variables used in this program. 1 ref., 13 figs.

7459 (SERI/TP–257-3558) **Inclusion of nonlinear aerodynamics in the FLAP code.** Weber, T. (Solar Energy Research Inst., Golden, CO (USA)). Solar Energy Research Inst., Golden, CO (USA). Nov 1989. 8p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC02-83CH10093. (CONF-900136–5: 9. ASME wind energy symposium, New Orleans, LA (USA), 14-17 Jan 1990). Order Number DE89009507. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Horizontal axis wind turbines usually operate with significant portions of the blade in deep stall. This contradicts the assumption in the FLAP code that a linear relation exists between the angle of attack and the lift coefficient. The objective of this paper is to determine the importance of nonlinear aerodynamics in the prediction of loads. The FLAP code has been modified to include the nonlinear relationships between the lift and drag coefficients with the angle of attack. The modification affects the calculation of the induced velocities and the aerodynamic loads. This requires an iterative procedure to determine the induced velocities instead of a closed form solution. A more advanced tower interference model has also been added that accounts for both upwind and downwind tower effects. 7 refs., 14 figs.

7460 (SERI/TP–257-3589) **Prediction of stochastic blade loads for three-bladed, rigid-hub rotors.** Wright, A.D.; Weber, T.L.; Thresher, R.W.; Butterfield, C.P. Solar Energy Research Inst., Golden, CO (USA). Nov 1989. 7p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC02-83CH10093. (CONF-900136–6: 9. ASME wind energy symposium, New Orleans, LA (USA), 14-17 Jan 1990). Order Number DE89009508. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Accurately predicting wind turbine blade loads and response is important for the design of future wind turbines. The need to include turbulent wind inputs in structural dynamics models is widely recognized. In this paper, the Force and Loads Analysis Program (FLAP) code will be used to predict turbulence-induced bending moments for the SERI Combined Experiment rotor blade and the Howden 330-kW blade. FLAP code predictions will be compared to the power spectra of measured blade-bending moments. Two methods will be used to generate turbulent wind inputs to FLAP: a theoretical simulation: the Pacific Northwest Laboratories (PNL) simulation theory; and measured wind-speed data taken from an array of anemometers upwind of the turbine. Turbulent wind-speed time series are input to FLAP for both methods outlined above. Power spectra of predicted flap-bending moments are compared to measured results for different wind conditions. Conclusions are also drawn as to the ability of the turbulence simulation models to provide accurate wind input to FLAP and to FLAP's ability to accurately simulate blade response to turbulence. Finally, suggestions are made as to needed improvements in the theoretical model. 11 refs., 8 figs.

7461 (STEV-VIND–89-16) **Analysis of synchronous generator with frequency convertor for electrical power generation with variable speed.** Carlson, Ola (Chalmers Univ. of Tech., Goeteborg (SE). Dept. of Electrical Machines and Power Electronics). Statens Energiverk, Stockholm (Sweden). Nov 1988. 13p. (In Swedish). Project STEV-506258. Order Number DE90728335. Available from NTIS (US Sales Only), PC A03/MF A01.

The aim of the system is to generate electrical power from a rotating source, in this case a windmill, with variable speed. The electrical system controls the torque in the generator and thereby the loads on the shafts and the gear box in the windmill. The analysis and tests of the system have passed three steps of development and evaluation. In the first step the system has been treated theoretically by transient state models and numerical calculations of the salient poles synchronous and slip-ringed induction generators, respectively, and the frequency convertor. The frequency convertor consists of a three-phase diode bridge and a current-controlled thyristor bridge as an inverter. In the next step the system has been tested in the laboratory, where mechanical torque and currents have been measured and analyzed with frequency analysis methods. The all over performance of the system and the efficiency were also measured. The last step was to install the electrical system, together with a digital control system, on a windmill. The experiences show optimal operation in winds below rated wind, and operation with constant torque in winds above rated wind. The successful operation was achieved as a result of the variable speed system. The theoretical calculations and practical measurements also indicated the presence of the harmonics in currents and in the electrical and mechanical torque, which are introduced by the convertor. The effects of the harmonics can be reduced by filters and by derating the generator. The efficiency of a system with only a

synchronous generator was compared with the system of a generator with convertor, and a slight decrease was measured for the system with the convertor.

7462 (STEV-VIND–89-19) **Preliminary blade design using integral computer codes.** Ryan, A. (Flygtekniska Foersoeksanstalten, Stockholm (Sweden)). Statens Energiverk, Stockholm (Sweden); Flygtekniska Foersoeksanstalten, Stockholm (Sweden). Dec 1988. 29p. Project STEV-506-266. (FFA-TN–1988-67). Order Number DE90728294. Available from NTIS (US Sales Only), PC A03/MF A01.

The aim of this study is to find relevant loads on the root section of a Horizontal Axis Wind Turbine (HAWT) rotor blade and to present a preliminary design solution for the root area. The loads on the blades are given by different load cases that are specified. To get a clear picture of the influence of different parameters, the whole blade is designed from scratch. This is only a preliminary design study and the blade should not be looked upon as a construction reference. The use of computer programs for the design and optimization is extensive. After the external geometry is set the aerodynamic loads calculated, parameters like design-stresses and laminate thickness are run through the available programs, and a blade design optimized on basis of facts and estimates used is presented. 16 illustrations, 13 references.

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Refer also to citation(s) 7627

7463 (HQ–89-04543) **Hydro Quebec's Technology, International Affairs and Research Institute Division: Progress report.** Hydro-Quebec, Montreal, PQ (Canada). 1987. 56p. (MICROLOG–89-04543). Available from PC Hydro-Quebec, Centre de diffusion, 75, boul. Dorchester ouest, 14e etage, Montreal, PQ, CAN H2Z 1A4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

This is the progress report of the TAI (Technology, International Affairs and Research Institute) division of Hydro Quebec for the year 1987. One hundred million dollars were invested in research, development and demonstration, including sixteen million from external contributions. TAI was involved in numerous collaborations with industrial partners and with about twenty countries around the world through the subsidiary Hydro Quebec International. Electricity-based development and demonstration have been increased; the equipment and operation of the electrical grid have been improved; the electromagnetic environment of conversion plants has been studied as have been automation, roots and equipment control; the Varennes tokomak for the study of nuclear fusion has been commissioned; the possible applications of high-temperature superconductors have been surveyed; agreements have been reached with various corporations to commercialize Hydro Quebec's inventions; the cooperation within Hydro Quebec to define the research objectives of the division has been extended. The LTEE (Laboratory of Electrochemical and Electrical Technologies) has also been commissioned. The new operating chart of the TAI division is given. 28 figs., 3 tabs.

7464 (HQ–89-05086) **Hydro Quebec's Technology, International Affairs and Research Institute Division. Report of activities, 1988.** Hydro-Quebec, Montreal, PQ (Canada). 1988. 59p. (MICROLOG–89-05086). Available from PC Hydro-Quebec, Centre de diffusion, 75, boul. Dorchester ouest, 14e etage, Montreal, PQ, CAN H2Z 1A4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

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Refer also to citation(s) 6508, 6516, 6517, 6519, 6788, 6791, 6805, 7181, 7582, 7856, 7858, 8153, 8154, 8155, 8169, 8181, 8182, 8201

7465 (CANWEC–CE-02836, pp. 17) **Decentralized medium size cogeneration plants: Report 4.1.7. .** Kiss, M. (Electrowatt Engineering Services Ltd., Zurich (Switzerland)); Hubler, J. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02836). In *Energy for tomorrow. Division 4: Energy and technology: Session 4.1: Energy research and development and other major energy technology issues.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Six case studies are presented to illustrate the utilization of cogeneration over a broad range of possible applications for housing, industry and district heating with electrical outputs ranging from 0.1 to 30 MW. These six projects may be summarized as follows: a gas engine with catalyzer which supplies heat and electricity for 250 housing units: (output 0.45 MW); a gas engine with catalyzer suppling steam and electricity for an industrial plant (output 0.41 MW); a combined cycle plant with gas turbine, heat recovery steam generator and steam turbine is being investigated for an industrial plant (output 9.6 MW); a heavy oil fired diesel engine with exhaust gas treatment supplies thermal electric power plus heat for a small district heating station (output 6.4 MWe); combustion of heavy oil in a fluidized bed boiler drives a steam turbine and supplies heat for a medium size district heating station (output 19.2 MW); and combined cycle plant with a gas turbine, a heat recovery steam generator and steam turbine for electricity generation plus heat for a medium size district heating station (output 31 MWe). Results show that with carefully optimised technology, cogeneration is economic over a wide range of applications, reduces emission levels and allows utilization of various fuel types. Proposals are presented to stimulate further utilization and extend the range of economic application. 5 figs.

7466 (CESI–86-9) **Dry type transformers: Performance tests and qualification procedures.** Caprio, G.; Yakov, S. Ente Nazionale per l'Energia Elettrica, Milan (Italy); Centro Elecctrotecnico Sperimentale Italiano, Milan (Italy). Jun 1986. 6p. (In Italian). Order Number DE89761905. Available from NTIS (US Sales Only), PC A02/MF A01.

In the performance testing of dry type transformers, not only electrical, but even environmental conditions play an important role. This is true especially with regard to dielectric stress withstand capabilities since the dielectric field is predominantly concentrated in the aerated zones where unfavourable atmospheric conditions can lead to considerable decay in dielectric rigidity. Testing procedures, normally employed for oil insulated transformers should therefore, in the case of dry type transformers, be modified to be able to ascertain compatibility between transformer type and the specific environmental conditions in which it must operate.

7467 (CESI–87-61) **Safety and electrical risk, with reference to lightning, discharges, fires, equipment malfunctioning, etc.** Thione, L. Centro Elecctrotecnico Sperimentale Italiano, Milan (Italy). Sep 1987. 14p. (In Italian). (CONF-8709394–: 88. annual meeting of the Italian Electrotechnical Association (AEI), Catania (Italy), 27-30 Sep 1987). Order Number DE89761900. Available from NTIS (US Sales Only), PC A03/MF A01.

Paper presented at 88th meeting of the Italian Electrotechnical Association (Catania, 27-30 Sep 1987).

The problems of safety in electrical systems are grouped into two main categories of risk: (1) problems connected with events external to the system and of natural or artificial origin; (2) problems connected with events and situations of an internal nature. The first category includes natural phenomena such as lightning, adverse atmospheric conditions and natural calamities. Artificial events are identified as deliberate attempts to damage property. Such events pose the most danger since they could lead to a series of danger affecting the internal part of the system (secondary causes). The second category groups breakdowns and failures due to equipment and component defects and degradation, electrical fires and explosions, maintenance and repair work and human factor errors

7468 (CMRC–8901, pp. 21-39) **Current status of Wakamatsu 50MW PBC demonstration plant.** Kanbe, Yoshio (The Coal Mining Research Centre, Japan, Tokyo, Japan); Fujita, Masao. Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Facilities of 50MW FBC demonstration plant are outlined, which are installed in the Wakamatsu thermal power plant of Electric Power Development Co., Ltd., and its coordination, commissioning operation and demonstration test since August, 1986 are outlined. The plant is composed of a coal/limestone supply facility, 156t/h FBC boiler, afterburner, turbine generator and antipollution facility. The test and real power generation are being carried out parallelly, and the plant is now under testing combined with an ultra-high temperature turbine for the development of ultra-high temperature/pressure coal thermal power plant. The plant passed the inspection after the coordination and commissioning operation in March, 1987, and thereafter, the verification test has being performed separately by the facility performance test to obtain the data of operation characteristics, reliability, profitability and practical plant design, and the combustion test to obtain the characteristic data of five kinds of coal. The plant aims to achieve the performance equivalent to that of a pulverized coal fired boiler. 11 figs., 5 tabs.

7469 (CMRC–8901, pp. 40-51) **Present status of combustion test of CPC boiler simulator.** Kanbe, Yoshio (The Coal Mining Research Centre, Japan, Tokyo, Japan); Nozoe, Shunpei. Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Test results of the boiler simulator for the CPC (coal pertial combustor) were reported, which is under development to substitute coal fired boilers for oil fired ones for general industry use. Combustion test were performed in three stages composed of the first and second stage using a semi water cooled combustor and the third stage using a jacket type full water cooled one. The first test was performed to enhance the test facility performance, the second was done with an additional automatic start/stop function and advanced data analysis function, and the third was done with an additional steady removal mechanism of combustor slag and desulfurizing agent supply equipment. As a result, the slag removal of the CPC reached up to 80% or more, and NOx emission (O_2 = 6% conversion) could be reduced to 150ppm or less. Dry ash in a boiler combustion chamber scarcely adhered on heating tubes or convection heating surfaces, while adhered ash could be easily removed by a soot-blower without any heat transfer reduction. 7 figs., 6 tabs., 2 photos.

7470 (CMRC–8901, pp. 75-84) **Development of high fineness vertical mill.** Yoshida, Hirohisa (Mitsubishi Heavy Indsutries, Ltd., Tokyo, Japan). Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Major technical problems during the development of a high fineness vertical mill and their solutions are reported, and the new vertical mill, 95% or more thru. 75micron sieve, equipped with a rotary separator is presented. The problems during high fineness grinding are mainly the mill vibration caused as coal on a table fails to pass under a roll favorably, and the remarkable increase in grinding power consumption caused by the increase in a specific surface of pulverized coal. As the solutions, the followings are given: the suitable separator shape possible to conduct effectively impinging separation, the suitable flow pattern possible to conduct smoothly the rise and drop of coal particles in the mill, and the grinding condition possible to maintain a suitable roll lift. Operation data of the new developed vertical mill, a mill load control system, and a technique to achieve a high turn down ratio are presented, and a MGI is also proposed as a grindability index of coal instead of a conventional HGI. 16 figs., 2 tabs.

7471 (CMRC–8902, pp. 141-161) **Wakamatsu 50MW fluidized-bed combustion boiler demonstration test update.** Yamaki, Tokizo (The Coal Mining Research Centre, Japan, Tokyo, Japan); Takeuchi, Masaru. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

The Wakamatsu 50MW fluidized bed combustion (FBC) boiler was introduced in aspect of facilities and result of demonstration test. In the FBC boiler, even low grade coal is combustible, which can amplify, in number of kinds, coal to be imported and simplify the desulfurizer as the desulfurization is possible inside the furnace. Such advantageous points being taken notice of, the Coal Mining Research Center, Japan and Electric Power Development, in collaboration with boiler manufacturers, have been proceeding with development of FBC boiler. That technical development was totally achieved and materialized in a form of wakamatsu 50MW FBC boiler, which has been demonstration tested since 1986. That boiler is characterized with a two-stage (upper and lower) FB construction for its future enlargement in capacity. The witness of operation as a business use power generation plant is the purpose of that test, which is mainly itemized into combustion characteristics, operation characteristics, reliability and economicality. As a result of test, the static characteristics of boiler showed, in both bed and steam temperatures, operation characteristics almost equal to the designed values, which could achieve the initial target. While concerning NOx and SOx, their lowering in content can achieve their respective taraget value. 13 figs., 8 tabs.

7472 (CONF-861005–1) **Eddy current testing of carbon steel tubes: The ENEL (Italy) experience on feedwater heaters.** Gabiccini, S.; Giovanelli, F.; Maciga, G.; Tarli, R. Ente Nazionale per l'Energia Elettrica, Pisa (Italy). Centro di Ricerca Geotermica. Oct 1986. 7p. From ASME joint power generation conference; Portland, OR (USA); 19-23 Oct 1986. Order Number DE89761891. Available from NTIS (US Sales Only), PC A02/MF A01.

Paper presented at ASME joint power generation conference (Portland, 19-23 Oct 1986).

The difficulties related to NDE (non-destructive examination) methodology employed in the inspection of feedwater heater of ferromagnetic tubes have promoted the development of an eddy current technique with a sizing capability of natural defects in small diameter tubes (ID=10 divided by 13 mm, with thickness ranging from 2 to 3 mm) of which reliability was verified by means of a round robin test exercise. ENEL (Italian National Electricity Board) adopts this technique to detect thickness reduction due to erosion-corrosion localized phenomena, expecially in the region of the tube supports. To cope with tube erosion-corrosion, representing the major cause of anavailability, the preventive plugging of damaged tubes is indicated as the fundamental action of planned maintenance. The paper also describes a method correlating the results of the rise in unit heat rate as a consequence of degraded tube pluggage. Through this method it is possible to evaluate the economical number of tubes to be plugged, the inspection frequency and the remaining life.

7473 (CPS–40-11/14-1989E, pp. 3A1-3A22) **Source test results of the Pigeon Point Energy Operating Facility, New Castle, DE.** Krick, C.S. (Delaware Dept. of Natural Resources and Environmental Control, New Castle, DE (USA)). Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA).

Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

The energy generating facility in Delaware which is described in this report fires a combination of refuse-derived fuel and municipal solid waste. The facility has 3 incinerators providing heat to 2 boilers on the north side, and 2 incinerators providing heat to 2 boilers on the south side. Each boiler has an electrostatic precipitator to control particulates. Testing of the facility was completed in 2 phases. The first phase consisted of an electrostatic precipitator net particulate, and stack particulate, sulfur oxides, and NOx, and HCl testing of all boilers. One run was accomplished during sootblowing operations. The second phase consisted of tests for dioxin/furan, and metals testing of one flue. The metals tested were As, Be, Cd, Cr, Pb, Hg, and Ni. The test results showed the facility to be in compliance with the permitted levels of particulate, sulfur dioxide, and NOx. The dioxin/furan and metals emissions were below those that would cause unacceptable ambient concentrations. 3 figs., 12 tabs.

7474 (CPS–40-11/14-1989E, pp. 4A15-4A28) **Jackson County (Michigan) resource recovery facility.** Hand, S.J. (Riley Energy Systems Corp. Worcester, MA (USA)); Dhargalkar, P.H. Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

A Michigan waste-to-energy facility has a capacity rating of 200 tons/day of municipal solid waste. Each of the two 100 ton/day unit streams represent current modern-day design and operating principles that are directly associated with environmental control. Each of the unit streams incorporates the Riley-Takuna stoker, combustion and boiler technology. The air quality control system consists of a dry scrubber and fabric filter supplied by Research-Cottrell. Performance trials were conducted, including trials for environmental control, whose test results show that all emissions were below state limits. Installation of the facility, and emission control performance, are described. 4 refs., 7 figs., 3 tabs.

7475 (CPS–40-11/14-1989E, pp. 4A1-4A14) **Air emissions test results from the Stanislaus County, California resource recovery facility.** Hahn, J.L. (Ogden Projects, Emeryville, CA (USA)); Sofaer, D.S. Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

A resource recovery facility began construction in California in August 1986, with commercial operation beginning in February 1989. This waste-to-energy plant uses the Thermal DeNOx process to reduce nitrogen oxide emissions to help meet its emission offset requirements under the Clean Air Act. In addition, it is the first large-scale facility in California to pass a rigorous environmental and health risk assessment process with review by the California Air Resources Board and the California Department of Health Services. The 800 ton/d facility comprises 2 waterwall boiler units with dry scrubbers and fabric filter baghouses to reduce acid gases and particulates, respectively. This facility generates about 20 MW of electricity, 15 MW of which are sold to Pacific Gas and Electric. About 400,000 residents of Modesto and parts of the rural San Joaquin Valley are served by this facility. Results of the testing for emissions of acid gases, nitrogen oxides, heavy metals, dioxins, and other trace organics are reported. The original health risk assessment is re-evaluated for cancer risk based on these actual emissions and the revised cancer risk is presented. For the 30-year and 70-year scenarios, the risk level is 11 and 20 times lower, respectively, than the levels originally reviewed. 4 refs., 2 figs., 8 tabs.

7476 (CPS–40-11/14-1989E, pp. 4A29-4A53) **Performance trends for the new Baltimore southwest facility: Projections and realities.** Feindler, K.S. (Beaumont Environmental Inc., Weatley Heights, NY (USA)). Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

A standard terminology has been developed for describing the performance of refuse-fueled power plants. Major parameters such as availability, utilization, load factors, and capacity factors have been defined for major equipment and systems. For cogenerating refuse-fueled power plants, total energy recovery efficiencies have been derived. Subsequently, ths standard terminology has been applied to the Saugus and Baltimore refuse-fueled power plants, where the first served as the reference plant for the second. Similarities in the behavior of both plants are discussed. For the Baltimore plant, trendlines show a decrease in waste processing capacity which may be related to changes in the waste stream. Finally, it is noted that increasing steam exports are responsible for a continued upward trend for winter peaks in overall energy recovery efficiency. 5 refs., 7 figs., 1 tab.

7477 (CPS–40-11/14-1989E, pp. 5A1-5A24) **Fluid-bed energy recovery facilities: Operating principles and environmental performance.** Minott, D.H. (Alternative Resources, Inc., Concord, MA (USA)). Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

While fluid-bed technology is well accepted for many industrial applications, only recently has it received serious consideration in the USA for municipal waste-to-energy applications. In this paper, the features of fluid-bed technology that distinguish it from conventional combustion technology for waste-to-energy applications are briefly reviewed. The operational and environmental attributes of fluid-bed technology are then addressed. Stack emissions test data, including data on dioxins, are presented for the one refuse-fired fluid-bed facility operating in the USA (in Duluth, Minnesota), and for such facilities operating in Scandinavia. In addition, toxicity test data for ash residues are presented. Overall advantages of fluid-bed combustion include high combustion efficiency, more stable combustion, lower combustion temperatures, in-situ desulfurization capability, multi-fuel capability, improved NOx suppression, and improved boiler efficiency. The test data indicate that refuse-fueled fluid-bed combustors achieve NOx emissions about 2/3 or less than those associated with conventional waste combustors. Dioxin

emissions are consistent with emissions from the most modern conventional combustors. Fly ash tested at a Swedish facility passes the Environmental Protection Agency toxicity test by a wide margin. 13 refs., 1 fig., 9 tabs.

7478 (CPS–40-11/14-1989E, pp. 5A65-5A82) **Combustion characterization of RDF [refuse derived fuel] incinerator technology: A joint Environment Canada - United States Environment Protection Agency Project.** Kilgroe, J.D. (U.S. Environmental Protection Agency, Research Triangle Park, NC (USA)); Finkelstein, A. Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

A joint Environment Canada/US Environmental Protection Agency project is being conducted to evaluate pollution and pollution control technologies associated with refuse-derived fuel facilities. This project involves comprehensive field tests at the Mid-Connecticut waste-to-energy facility, which incorporates a municipal solid waste processing plant and 3 spreader-stoker refuse-derived fuel combustors. Emissions from each combustor are controlled by a lime spray dryer and fabric filter baghouses. A primary objective of the test program is to develop correlations between combustion process conditions and furnace emissions. Adjunct activities include evaluation of the flue gas cleaning equipment and combustion facility residues. The field test project is divided into 2 test phases: characterization tests and field tests. This paper discusses the result of the combustion evaluations conducted during the characterization test phase. Two tentative conclusions are as follows. Good combustion as measured by CO emission is highly sensitive to load, excess air levels, and distribution/mixing of combustion air. The combustion conditions in spreader-stoker refuse-derived fuel combustors can be controlled to provide average CO emissions below 100 ppM. 8 refs., 4 figs., 3 tabs.

7479 (DOE/MC/21023–2747) **Second-generation pressurized fluidized bed combustion plant commercialization plan: Task 4 report: Topical report.** Hirschenhofer, J.H.; Robertson, A.S. Foster Wheeler Development Corp., Livingston, NJ (USA). Feb 1989. 107p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC21-86MC21023. Order Number DE90000406. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

This report presents a plan for moving coal-fired second-generation pressurized fluidized bed (PFB) combustion plants from their present conceptual stage to and through the sale of the first commercial electric utility plant by 2000; market penetration analyses are also included. A second-generation PFB plant can operate with an efficiency of 45 percent (based on the higher heating value of the coal used as fuel) and achieve a cost of electricity at least 20 percent lower than that of a conventional pulverized-coal-fired plant with wet-limestone flue gas desulfurization. Compared with conventional and other newly emerging power plant technologies, projections indicate that the proposed plant should capture a market share of 12.7 percent in 2010 and of 60 percent in 2020. A second-generation PFB combustion plant integrates a coal pyrolyzer/carbonizer with a circulating pressurized fluidized bed combustor (CPFBC). Char produced in the carbonizer is burned in the CPFBC, and the low-Btu fuel gas produced in the carbonizer is burned in a topping combustor to heat the CPFBC exhaust gas to 2100°F and higher before it enters a gas turbine. The carbonizer and CPFBC operate with lime-based sorbents for in-situ sulfur capture at $\leq$1600°F. Components being developed for first-generation PFB combustion plants protect the gas turbine from corrosion, erosion, and deposition. 23 refs., 35 figs., 24 tabs.

7480 (DOE/MC/23077–9) **Engineering support services for the DOE/GRI (Department Of Energy/Gas Research Institute) Coal Gasification Research Program: Progress report, October 1, 1988–December 30, 1988.** Foster Wheeler USA Corp., Clinton, NJ (USA). [1989]. 19p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC21-86MC23077. Order Number DE90004018. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The objective of this contract is to provide technical support for the Department of Energy (DOE)/Gas Research Institute (GRI) Joint Operating Committee, which oversees and administers the DOE/GRI Joint Coal Gasification Research Program. The general scope of these support services consists of technical assistance in the following areas: evaluation of modular coal gasification combined cycle power systems; plant operating requirements; to report on results presented at a debriefing on hot gas cleanup; economic analysis; and an analysis of IGT's high pressure gasification. This report provides a brief description on the following: economic sensitivity analysis as to the base cost of electricity for five IGCC case studies with respect to coal cost, general facilities cost, and zinc ferrite usage. A survey on coal gasification technology is also provided. (CBS)

7481 (DOE/MC/23077–10) **Engineering support services for the DOE/GRI Coal Gasification Research Program: Technical progress report, December 31, 1988–March 31, 1989.** Foster Wheeler USA Corp., Clinton, NJ (USA). [1989]. 19p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC21-86MC23077. Order Number DE90004017. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The objective of this contract is to provide technical support for the Department of Energy (DOE)/Gas Research Institute (GRI) Joint Operating Committee, which oversees and administers the DOE/GRI Joint Coal Gasification Research Program. The general scope of these support services consists of technical assistance in the following areas: evaluation of modular coal gasification combined cycle power systems; plant operating requirements; to report on results presented at a debriefing on hot gas cleanup; economic analysis; and an analysis of IGT's high pressure gasification. This report presents progress on the use of zinc ferrite and zinc titanate as desulfurization sorbents. 4 refs., 4 figs., 2 tabs.

7482 (ENEL–53-86-F) **NDE and economic factors involved in the maintenance of feedwater heaters.** Gabiccini, S.; Giovanelli, F.; Maciga, G.; Tarli, R. Ente Nazionale per l'Energia Elettrica, Pisa (Italy). Centro di Ricerca Geotermica. Oct 1986. 14p. (CONF-861005–: ASME joint power generation conference, Portland, OR (USA), 19-23 Oct 1986). Order Number DE89761892. Available from NTIS (US Sales Only), PC A03/MF A01.

Paper presented at ASME joint power generation conference (Portland, 19-23 Oct 1986).

The economic impacts of feedwater heater performance are stressed: the most common failures and the probable causes are briefly shown; the diagnostic techniques and the correcting actions, currently in use in power generating plants, are described. The difficulties related to NDE (non-destructive examination) methodology employed in the inspection of ferromagnetic tubes have promoted the development of an Eddy Current technique with a sizing capability of natural defects in small diameter tubes (OD=16-19 mm, with thickness ranging from 2 to 3 mm) of which reliability was verified by means a Round Robin Test exercise. ENEL (Italian National Electricity Board) adopts this technique to detect uniform thickness reduction due to erosion-corrosion localized phenomena, expecially in the region of the tube support. To cope with tube erosion-corrosion, representing the major cause of unavailability, the preventive plugging of damaged tubes is indicated as the fundamental action of planned maintenance. The paper also describes a method correlating the results of the rise in unit heat rate as a consequence of damaged tube plugging. Through this method, it is possible to evaluate the economical number of tubes to be plugged, the inspection frequency and the tube remanent life.

7483 (EPRI-CS–5588-Vol.4) **Remaining-life estimation of boiler pressure parts: Volume 4, Metallographic models for weld-heat-affected zone: Final report.** Ellis, F.V. (Combustion Engineering, Inc., Chattanooga, TN (USA)); Henry, J.F.; Shammas, M.S. Electric Power Research Inst., Palo Alto, CA (USA); Combustion Engineering, Inc., Chattanooga, TN (USA). c Nov 1989. 166p. Sponsored by Electric Power Research Institute. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

A comprehensive program of interrupted and creep rupture tests were performed on two heats of 1Cr-1/2Mo steel in a simulated coarse-grained HAZ condition at temperatures in the range 535-635°C using both uniaxial and biaxial (torsion) stress states in order to produce specimens with varying degrees of creep damage. Based on studies of creep cavitation in these 1Cr-1/2Mo steel HAZ specimens, a quantitative metallographic parameter, 'A', was developed which describes the state of cavitation damage. The 'A' parameter is defined as the number fraction of grain boundaries having visible cavitation (OLM in the range of 400X to 500X) measured in traverses parallel to the maximum principal stress axis. The accumulation of creep damage as measured by the 'A' parameter was shown to be independent of stress state and, within the normal ranges of etching, insensitive to etch contrast since cavities need simply to be resolved. Thus, it is ideally suited to field measurements of service induced damage in plant components. Recommended metallographic preparation, replication and 'A' parameter measurement procedures are described. 56 refs., 70 figs., 17 tabs.

7484 (EPRI-GS-6595) **Planned outage reduction for combustion turbines and combined-cycle plants: Final report.** Hughes, J. (Creole Production Services, Inc., Houston, TX (USA)); Carlton, J.; Wills, R.; Wicke, J. Electric Power Research Inst., Palo Alto, CA (USA); Creole Production Services, Inc., Houston, TX (USA). c Dec 1989. 29p. Sponsored by Electric Power Research Institute. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

This publication presents summary information intended to be used by EPRI members and other owner/operators of General Electric Frame 7 and Westinghouse 501 PACE combined cycle plants in developing detailed overhaul plans. These planning recommendations and overhaul data were developed through review of overhaul plans used by several EPRI members, on-site monitoring of overhauls, review of reports and papers from several sources including EPRI, discussions with manufacturers representatives, and the experience of the contractors field maintenance and engineering staff. The gas turbine overhaul plan, available through the Electric Power Software Center, provides the building blocks for a User to develop detailed overhaul plans for each individual unit which can be updated and re-used over the life of the equipment. That plan is presented in both hard copy and on computer diskettes. This report, available through the EPRI Research Reports Center, contains the recommendations resulting from the project.

7485 (EPRI-NP-6565) **Operation of the EPRI Nondestructive Evaluation Center: 1988 annual report.** Stone, R.M. (Jones (J.A.) Applied Research Co., Charlotte, NC (USA)); Ammirato, F.V.; Becker, F.L.; Bremser, K.; Krzywosz, K.J.; MacDonald, D.E.; Nottingham, L.D.; Selby, G.P.; Shankar, R.; Stephens, H.M. Electric Power Research Inst., Palo Alto, CA (USA); Jones (J.A.) Applied Research Co., Charlotte, NC (USA). c Nov 1989. 170p. Sponsored by Electric Power Research Institute. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

This report describes the Electric Power Research Institute (EPRI) funded nondestructive evaluation (NDE) and life assessment project activities carried out at the EPRI NDE Center in 1988. The primary support for this program is provided through contract RP 1570-2 with the EPRI Nuclear Division. Supplementary funding is provided by other contracts with the EPRI Nuclear, Coal Combustion, and Electrical Systems Divisions. The major objective of this program is to provide improved and field-qualified NDE equipment, procedures, and personnel training to the electric utility industry. A second program objective involves the validation, provision, and maintenance of life assessment codes for selected plant components. Significant assistance has been provided to the utility industry under this project in the form of improved, field-ready equipment and procedures; critically needed assessments of inspection method capability; demonstrations of effectiveness of examination methods; rapid response for critical, short-term problems; assistance with selected life assessment computer codes; and training for specific utility industry needs. These efforts have specifically involved heat exchanger, piping, steam turbine, generator, and heavy section problems. Certain components of both nuclear and fossil plants have been addressed. 56 refs., 48 figs., 13 tabs.

7486 (LBL-27954) **Development and evaluation of a superior heat recovery design for gas-turbine systems using gasified coal.** Russell, J.V.; Lynn, S. Lawrence Berkeley Lab., CA (USA). Aug 1989. 102p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC03-76SF00098. Order Number DE90004026. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

Thesis. Submitted by J.V. Russell.

This study investigates the impacts of high- and medium-temperature coal-gas clean-up methods on the thermal efficiency of coal-gas turbine systems for power generation, and the development of a novel heat-recovery design that improves the thermal efficiency of systems using medium-temperature clean-up. High-temperature clean-up cools hot coal gas (1850°F-2400°F) to 1200°F by evaporation of water; medium-temperature clean-up saturates the hot coal gas to about 400°F with evaporated water. The effect of using different methods of coal gasification is explored using a Texaco oxygen-fed gasifier and two fluid-bed gasifiers; one fed with oxygen, the other with air. The effect of different gasifiers on thermal efficiency is also investigated using the ISTIG design. The novel heat-recovery design is introduced and its performance is investigated with the three gasifiers. 8 refs., 23 figs., 15 tabs.

7487 (NAL-SP-9, pp. 9-14) **Numerical calculation method for three-dimensional flows in the dump diffuser of gas turbine combustor.** Ando, Yasunori (Ishikawajima-Harima Heavy Industries, Co., Ltd., Tokyo (Japan)); Kawai, Masafumi; Sato, Yukinori; To, Hidemi. National Aerospace Lab., Chofu, Tokyo (Japan). Dec 1988. (In Japanese). In *Special publication of National Aerospace Laboratory. Proceedings at the 6th NAL symposium on aircraft computational aerodynamics.* Order Number DE89910195. Available from NTIS (US Sales Only), PC A12/MF A01.

In order to investigate the dump diffuser in flow field characteristics, an analytical method of two/three-dimensional incompressible viscous flow by the finite volume method, based on the general curvilinear coordinates, was developed. Among the recent inlet diffusers of gas turbine combustor, the dump diffuser is taken notice of and has however not been elucidated in characteristics. A standard κ-ϵ two-equational model being applied to the turbulence model, a governing equation of flow field was derived and converted into the general curvilinear coordinates. Then, to numerically analyze it, a difference equation was introduced, by using the finite volume method, and integrated to derive an algebraic equation, which was solved by a supercomputer. In order to verify the above calculation method in calculation accuracy and usefulness as a design tool, the degree in visuality, and both velocity and pressure distributions, of the flow were measured, by using an experimental unit, and compared in result with those upon calculation. In the comparison result, the measurement and calculation both qualitatively and quantitatively almost coincided with each other, which confirmed the above prediction method to be effective. 8 refs., 9 figs., 1 tab.

7488 (NAL-TR-975T) **Secondary flows and losses in two types of straight turbine cascades (2). Rotor case.** Yamamoto, Atsumasa; Usui, Hiroshi; Mimura, Fujio. National Aerospace Lab., Chofu, Tokyo (Japan). May 1988. 18p. Order Number DE89910183. Available from NTIS (US Sales Only), PC A03/MF A01.

To obtain some experimental data of secondary flows and associated total pressure losses occurring in turbine cascades, generation and development mechanisms were examined of the total pressure loss in a straight rotor cascade with a large turning angle of about 102 deg. To make clear a loss transfer and accumulation process over the surface of cascade passage, superimposed secondary flow vectors and loss contours were given at 12 serial traverse planes located before, in and after the cascade, and distributions of static pressures and losses were given on various planes close to blade surfaces and an endwall surface. Furthermore, variation of mass-averaged flow angle, velocity and loss through the cascade, and evolution of overall loss from upstream to downstream of the cascade were given. As a result, in the case of the large turning angle, evolution of overall loss started in an earlier stage within the cascade, and the loss growth rate was much larger than that in the stator. 11 refs., 9 figs.

7489 (NAL-TR-985T) **Mechanisms of endwall/leakage flows and the associated losses in a linear turbine rotor cascade with blade tip-clearance.** Yamamoto, Atsumasa; Kaba,

Katsuyoshi. National Aerospace Lab., Chofu, Tokyo (Japan). Jun 1988. 23p. Order Number DE89910185. Available from NTIS (US Sales Only), PC A03/MF A01.

The generation mechanisms of three-dimensional flows and associated losses were discussed, which occurred in the tip endwall region of a linear turbine cascade with tip-clearance. Clearance gap sizes and cascade incidences (inlet flow angle) were chosen as the most important variables affecting the generation mechanisms, and they were tested in several values using a low-speed linear cascade wind tunnel. Flows close to the endwall and inside the clearance were precisely measured by a micro five-hole pitot tube of 0.6mm in head size. As a result, various detailed information of the loss generation mechanisms were obtained such as leakage flow vectors and pressure distributions throughout the tip-clearance. Interaction of leakage flow with surface flow on the endwall, their associated separation lines, effects of the gap size and inlet flow angle on loss generation, and skewness of the three-dimensional endwall flows were also discussed. 17 refs., 15 figs., 1 tab.

7490 (OH/RD–88-199-K) **Evaluation of cracks in the Lambton TGS [thermal generating station] unit 3 boiler circulation pump suction manifold nozzles.** Scarth, D.A. Ontario Hydro Research Div., Toronto, ON (Canada). 22 Feb 1989. 62p. (MICROLOG–89-04431). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

Circumferential cracks have been found in the boiler circulation pump suction manifold nozzles in Lambton Thermal Generating Station Unit 3. The deepest cracks are 20 mm deep. An evaluation of the structural integrity of these cracked nozzles has been completed. The safety margins against fracture initiation and against plastic collapse for the worst case 20 mm deep cracks are 2.66 or greater for normal operating conditions. The safety margins against fracture initiation for the worst case 20 mm deep cracks under hydrostatic test conditions are 1.87 or greater. The cracked nozzles were found to be acceptable for continued service. It was recommended that a hydrostatic test be performed on the suction manifold assembly prior to bringing unit 3 back into service and that the cracked nozzles be monitored by means of a periodic inspection program. 13 refs., 24 figs., 13 refs.

7491 (OH/RD–88-292-K) **Evaluation of cracks in the Lambton TGS [thermal generating station] unit 3 boiler circulation pump casings and discharge value bodies.** Scarth, D.A. Ontario Hydro Research Div., Toronto, ON (Canada). 14 Nov 1988. 81p. (MICROLOG–89-04430). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

Cracks have been found in the boiler circulation pump casings and discharge valve bodies in Lambton Thermal Generation Station Unit 3. The deepest cracks not repaired in the pump casing are 3 mm deep, and the deepest cracks not repaired in the discharge valve bodies are 10 mm deep. An evaluation of the structural integrity of both components with cracks of various depths has been completed. The safety margins against fracture initiation and against plastic collapse for the existing cracks are all above 4.0. The existing detected cracks are acceptable for continued service. The deepest crack detected in the pump casings, and subsequently this crack under normal operating pressure was 1.82 for fracture initiation, and 1.68 for plastic collapse. The deepest crack detected in the discharge valve bodies, and subsequently repaired, was 55% through the wall thickness. The safety margins for this crack under normal operating pressure was 2.89 for fracture initiation, and 3.48 for plastic collapse. It was recommended that all of the boiler circulation pumps and discharge valves be subjected to periodic hydrostatic tests, and be monitored by means of a periodic inspection program. The mechanism of crack growth has not been identified; the author suggests that it might be a corrosion-related fatigue mechanism. 18 refs., 37 figs., 10 tabs.

7492 (OH/RD–88-326-K) **Generator condition monitors. Comparison of heated and unheated ion chambers.** Braun, J.M. Ontario Hydro Research Div., Toronto, ON (Canada). 2 Feb 1989. 17p. (MICROLOG–89-04304). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

The generator condition monitor (GCM) was developed in an attempt to detect overheating inside large turbine generators. Their performance and value to operators are still subjects of discussion. As part of a broader study involving also tagging compounds, two different Environment One generator condition monitors were evaluated under field conditions at Nanticoke Thermal Generating Station using small resistors coated with conventional insulating paints and varnishes and controlled through the instrumentation feed-through panel. The GCM responded very rapidly to an overheating event, typically within two minutes, even for hot spots as small as 10 cm^2. Similarly, the aerosols produced on overheating were extremely short-lived, decaying within two to three minutes after overheating was discontinued. Use of heated ion chambers was found to desensitize the GCM, regardless of the nature of the overheated insulation, and, in some cases, would altogether prevent the GCM from reaching the 50% pre-set alarm level commonly used on GCMs. Use of heated ion chambers is generally not recommended, except where severe oil mist problems may exist. 13 refs., 10 figs., 1 tab.

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Refer also to citation(s) 6516, 6517, 6756, 6757, 7477, 7679, 8169, 8184, 8185, 8389

7493 (CPS–40-11/14-1989E, pp. 4B11-4B24) **Semi-industrial testing of the 3R process.** Vehlow, J. (Kernforschungszentrum Karlsruhe Gmbh, Karlsruhe (Germany)); Braun, H.; Schneider, J.; Vogg, H.; Horch, K. Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

The 3R process is a method of inertizing the flue dust from refuse incineration. Plants equipped with wet flue gas cleaning systems offer particular advantages in this respect. In the first process step, mobile heavy metals are extracted from the dusts by treatment with the acidic solution of the first scrubber. In a second step, the remaining solid residues are recycled into the incinerator to destroy attached organic pollutants. A pilot plant has been built for testing the process on a semi-industrial scale. It processed 10% of the filter dusts and the flue gas scrubbing water of a municipal solid waste incinerator having a throughput of 20 tons/h. The following results were achieved in 3 measurement campaigns of 2 weeks each. The extraction yields of the most important heavy metals are nearly constant in the range of liquid/solid ratios and pH levels expected to occur during operation on a technical scale. The attainable extraction yields are about 90% for Cd, 60% to 70% for Zn, and about 20% for Pb an Cu. Compaction and subsequent thermal treatment of the leached 3R residues in the incinerator of a municipal solid waste incineration plant generates products which comply easily with the limits of the Swiss eluate test. 9 refs., 8 figs., 3 tabs.

7494 (CPS–40-11/14-1989E, pp. 4B25-4B44) **Evaluation of leachate properties and assessment of heavy metal immobilization from cement and lime amended incinerator residues.** Holland, P.J. (Univ. of New Hampshire, Durham, NH (USA)); Collins, M.R.; Gress, D.L.; McHugh S.A.; Eighmy, T.T. Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood,

FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

The ability of Type II Portland cement and hydrated lime to solidify and stabilize municipal solid waste incinerator residues was evaluated. Dynamic column leach tests were performed on the unamended combined residue (92% bottom to 8% fly ash), as well as crushed cement and lime-amended residues blended in a 1:5 and 1:19 (dry weight) ratio, respectively. The columns were run in a downflow, fully saturated configuration using a pH 4.0 synthetic acid rain leaching medium. Leachate withdrawal was controlled at 0.15 ml/min until final liquid/solid ratios of 0.6, 0.4, and 0.9 were achieved in the cement, lime, and residue control columns. The leachates were analyzed for heavy metal and anion concentrations, pH, conductivity, alkalinity, and redox potential. Successful immobilization of all the tested metals except Al, Pb, and Ni were seen in the cement-amended leachates, while only Zn and Mn were leached from the lime-amended columns in concentrations exceeding those found in the residue control. Compressive strength tests were performed on 3 different cement-amended matrices and 2 lime-amended matrices as a measure of residue solidification. Average 28 day compressive strengths ranged from 280 to 780 psi in the cement matrices, while the lime matrices achieved compressive strengths between 4 and 25 psi. This research represents an ongoing effort in evaluating solidification and stabilization amendments for municipal solid waste incinerator residues. The primary focus of these efforts is to minimize metal leachability by optimizing residue/amendment mix designs, and to evaluate the resulting matrices' potential for reuse applications in the construction industries. 22 refs., 15 figs., 3 tabs.

7495 (CPS–40-11/14-1989E, pp. 5B1-5B14) **Sorted incinerator slag used as fill material.** Hartlen, J. (Swedish Geotechnical Inst., Linkoeping (Sweden)); Rogbeck, J. Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

In Sweden, 400,000 tons of incinerator slag is produced per year. So far only a small portion is utilized. To increase the value of the slag, a special product is produced by screening and magnetic separation. This product is called ash-gravel and its proportion of the total slag amount is 70 per cent. Results are presented from laboratory and field tests performed to clarify the properties of ash-gravel as a fill material to substitute for natural sand and gravel. Special emphasis is directed to compaction properties, effect of slag age and risk of crushing due to compaction. Experience has shown that it is important to sort the slag, thus eliminating uncombusted and metallic materials. Compaction tests in the field have shown that good performance is obtained with a sorted slag stored for at least 1 year. Fresh ash-gravel has proved to be unsuitable, even though laboratory tests did not indicate any difference in comparison with aged ash-gravel. The reason for this inferior performance is believed to be mainly the higher water content of the fresh ash-gravel. 6 refs., 7 figs., 4 tabs.

7496 (CRIE-U–88040) **Weathering mechanism of sandstone (Part 2). Weathering of fine-grained sandstone.** Chigira, Masahiro. Central Research Inst. of Electric Power Industry, Abiko, Chiba (Japan). Dec 1988. 41p. (In Japanese). Order Number DE89910295. Available from NTIS (US Sales Only), PC A03/MF A01.

Large electric power facilities are increasingly constructed on sites of sedimentary soft block since Neogene Period, so that weathering mechanism of sandstone was studied. Weathered sandstone in a mountainous area, Niigata Prefecture, Japan consists of yellowish-brown oxidation zone from the surface to 28m depth, dissolution zone to 40m depth, dissolution-transition zone and Pliocene sandstone. The weathering zone has a pair of weathering fronts: an oxidation front in its middle part and a dissolution front in its lower part. At the oxidation front, pyrite and chlorite are lost and iron oxide and hydroxide are precipitated. At the dissolution front, the matrix cementing sand grains is dissolved, smectite decreases and volcanic glass is obviously dissolved. The formation of weathering zone is caused by the interaction between rock and moisture in air saturated with oxygen, and oxygen oxides pyrite and chlorite in the oxidation front to form sulfuric acid. This sulfuric acid dissolves volcanic glass and smectite to form the dissolution zone. 28 refs., 15 figs., 3 tabs.

7497 (DOE/PC/88865–T2) **Ambient flow studies and particulate collection measurements: A laminar flow, reduced entrainment electrostatic precipitator.** Greiner, G.P.; Furlong, D.A.; Bahner, M.A. ETS, Inc., Roanoke, VA (USA). May 1989. 142p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC22-88PC88865. Order Number DE90001457. Available from NTIS, PC A07/MF A01 - OSTI; GPO Dep.

This report describes ambient temperature testing of an electrostatic precipitator having a portion of the main precipitator flow drawn through porous (fabric) plates. The effects of flow through the plates (side flow) on precipitator turbulence and particulate removal efficiency are investigated. Ambient temperature particulate removal efficiency measurements are conducted on both indoor air dust, and on injected coal fly ash. 24 figs., 10 tabs.

7498 (DOE/PC/88873–T4) **In-duct slurry droplet process model: Topical report No. 2.** Energy and Environmental Research Corp., Irvine, CA (USA). 1 Jul 1989. 100p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC22-88PC88873. Order Number DE90001466. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

This report describes a model whose primary goal is to calculate the amount of SO_2 which would be captured when calcium based sorbents and water are injected into the duct of a coal fired power plant. The model also considers the humidification and condensation processes and the scavenging of sorbent suspended in the duct by a spray of water. The fundamental basis of the model, the model's structure, and operation of the model are discussed. Examples of input data files and the corresponding output, a listing of the computer code, and a list of the major variables used in the computer code are given. 3 refs., 8 figs.

7499 (ENEA-RT-STUDI–85-2) **Comparative evalutation of wastes produced by coal and oil fired thermoelectric power stations.** Bocola, W. ENEA, Casaccia (Italy). Centro Ricerche Energia. 1985. 10p. (In French). Order Number DE89761957. Available from NTIS (US Sales Only), PC A02/MF A01.

Extract from Revue Generale de Thermique (France); No. 276, Dec 1984, pp 866-872.

The main characteristics of residuals associated with the normal operation of coal and oil fired power stations are presented and discussed, with special emphasis given to airborne emissions due to combustion processes. Whenever possible, this characterization was done on the basis of the available information concerning the Italian power stations, with special reference to the Vado Ligure (coal fired) and La Casella (oil fired) power plants. When national data were not available, data coming from the most recent international literature were taken into account.

7500 (EPRI-GS–6423-Vol.2, pp. 6B.1-6B.20) **Prediction of fuel and thermal NO in advanced combustion systems.** Boardman, R.D. (Brigham Young Univ., Provo, UT (USA)); Smoot, L.D. Electric Power Research Inst., Palo Alto, CA (USA); Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. Jul 1989. DOE Contract AC21-86MC23075. (CONF-890318–Vol.2: Joint symposium on stationary combustion nitrogen oxide control, San Francisco, CA (USA), 6-9 Mar 1989). In *1989 symposium on stationary combustion nitrogen oxide control. Volume 2.* Order Number DE89016350. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

A computer model to predict in-situ and effluent nitric oxide (NO) concentrations has been applied to advanced-concept, pulverized-coal systems and evaluated by comparing model predictions with experimental data. Specifically, the effects of pressure, stoichiometric ratio, air stage location, and temperature were predicted by the model and compared to experimental data. An overview of the model theory and its approach is presented. The basis for an expanded model including thermal NO and alternative fuel NO mechanisms to explore the capabilities of predicting low rank coal behavior and possibly fuel-staging (reburning) is discussed. This work is a continuation of previous model development and evaluations.

7501 (EPRI-GS–6423-Vol.2, pp. 6B.39-6B.60) **Reduction of fuel-NO by increased operating pressure in a laboratory-scale coal gasifier.** Nichols, K.M. (Chemical Sciences Div., Appleton, WI (USA)); Hedman, P.O.; Blackham, A.U. Electric Power Research Inst., Palo Alto, CA (USA); Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. Jul 1989. (CONF-890318–Vol.2: Joint symposium on stationary combustion nitrogen oxide control, San Francisco, CA (USA), 6-9 Mar 1989). In *1989 symposium on stationary combustion nitrogen oxide control. Volume 2.* Order Number DE89016350. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

Measurements of NO during laboratory-scale gasification of a Utah bituminous coal verified that small increases in pressure (from 1 to 2 atm) at constant residence time resulted in dramatic decreases in effluent NO levels. Tests were conducted at 3 target levels of pressure (1, 2, and 4 atm) and 2 target levels of residence time (450 and 900 ms). Oxygen-to-coal ratio for all tests was 0.90 (SR = 0.45). The dominant factor in causing lower effluent NO levels was the increased kinetic rate of NO decay. Increased residence time in the fuel-rich gasifier contributed to lower effluent NO levels, but was of minor importance when compared to the effect of pressure on the decay rate. Concentrations of N_2 appeared to be slightly increased and concentrations of TFN decreased as pressure was increased. Neither TFN or N_2 concentrations were affected by increasing residence time. For all tests, nitrogen conversion exceeded carbon conversion by about 10%. Neither nitrogen conversion nor carbon conversion was found to increase with increasing pressure. Both increased slightly (4-5%) with increasing residence time, evidence that most of the coal nitrogen and carbon was released during devolatilization.

7502 (EPRI-GS–6519, pp. 10.1-10.15) **Development status of the NOXSO combined NO_x/SO_2 flue gas treatment process.** Hasibeck, J.L. (NOXSO Corp., Library, PA (USA)); Neal, L.G.; Ma, W.T. Electric Power Research Inst., Palo Alto, CA (USA). Sep 1989. DOE Contract FC22-85PC81503. (CONF-880326–: 4. symposium on integrated environmental control, Washington, DC (USA), 2-4 Mar 1988). In *Proceedings: Fourth symposium on integrated environmental control.* Order Number DE90000517. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

The NOXSO process is a dry, flue gas treatment process that removes 90% of the SO_2 and NO_x from the flue gas generated by coal-fired boilers. The flue gas is cleaned as it passes through a fluidized bed of solid sorbent at a temperature of 120°C. Spent sorbent is regenerated for reuse by treatment with a reducing gas at 600°C. The regeneration produces SO_2 and H_2S which are converted to elemental sulfur in a Claus reactor. The sulfur is sold as a by-product. The NOXSO process generates no waste. Adsorbed NO_x desorbs as the sorbent is heated to 600°C. The sorbent is heated with hot air in a fluidized bed. The hot air leaving the sorbent heater and containing NO_x is mixed with the combustion air fed to the coal burner. The recycled NO_x suppresses the production of NO_x in the coal combustor, so that the concentration of NO_x in the flue gas increases slightly but achieves a new steady state. The NOXSO process flowsheet is shown in Figure 1. This paper summarizes the results of a test of the NOXSO process at DOE's Pittsburgh Energy Technology Center (PETC) and provides a comparison of economic data for NOXSO with other systems. The process has been tested previously at smaller scale on actual flue gas at TVA's Shawnee Steam Plant. The results of these earlier tests may be found in two published reports.

7503 (EPRI-GS–6519, pp. 7.1-7.15) **Combined NO_x/SO_2 removal for high sulfur coal.** Livengood, C.D. (Argonne National Lab., IL (USA)); Farber, P.S.; Harkness, J.B.L. Electric Power Research Inst., Palo Alto, CA (USA). Sep 1989. DOE Contract W-31-109-ENG-38. (CONF-880326–: 4. symposium on integrated environmental control, Washington, DC (USA), 2-4 Mar 1988). In *Proceedings: Fourth symposium on integrated environmental control.* Order Number DE90000517. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

Argonne National Laboratory (ANL) has been conducting research on combined nitrogen oxides (NO_x) and sulfur dioxide(SO_2) control since 1981. Technologies applicable to both retrofit and new installations have been investigated, with particular emphasis on applications involving high-sulfur coal. Significant progress has been made in using chemical additives to enhance NO_x removal in conventional wet scrubber chemistries, with removals of 79-90% attained in laboratory experiments. Economic estimates based on a preliminary process design indicate that the technique should be competitive with commercially available alternatives. Other research has identified chemical additives that promote NO_x removal by dry sorbents and in spray drying systems, and has identified key parameters for dry NO_x/SO_2 control such as flue-gas temperature, SO_2 and NO_2 levels, and the degree of gas-solid contact (filter-cake thickness). Tests of combined NO_x/SO_2 removal have been carried out in a commercial-scale (20 MWe) spray dryer system that has also been used to demonstrate effective SO_2 control with high sulfur coal.

7504 (EPRI-GS–6519, pp. 8.1-8.12) **Sorbent life cycle testing fluidized-bed copper oxide process.** Shah, P.P. (UOP Inc., Des Plaines, IL (USA)); Leshock, D.G. Electric Power Research Inst., Palo Alto, CA (USA). Sep 1989. DOE Contract AC22-85PC81004. (CONF-880326–: 4. symposium on integrated environmental control, Washington, DC (USA), 2-4 Mar 1988). In *Proceedings: Fourth symposium on integrated environmental control.* Order Number DE90000517. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

The Fluidized-Bed Copper Oxide process is a promising new technology being developed to simultaneously remove sulfur dioxide and nitrogen oxide contaminants from the flue gas of coal-fired utility boilers. This dry and regenerable process uses a copper oxide sorbent in a fluidized-bed reactor. Contaminants are removed in a relatively simple fashion without generating waste material. The Pittsburgh Energy Technology Center (PETC) of the US Department of Energy has demonstrated the technical and economic potential of the Fluidized-Bed Copper Oxide process through several stages of bench and pilot plant testing. UOP Inc. has continued this effort in a testing program completed with a 100 SCFM Life-Cycle Test unit. During this testing, UOP confirmed that the process is capable of simultaneously removing 90 vol-% of the sulfur dioxide and nitrogen oxide contaminants from coal-derived flue gas.

7505 (EPRI-GS–6519, pp. 9.1-9.12) **Field evaluation of combined NO_x/SO_2 control via gas reburning-sorbent injection for coal-fired utility boilers.** Bartok, W. (Energy and Environmental Research Corp., Irvine, CA (USA)); Folsom, B.A.; Moyeda, D.; Nelson, L.P.; Payne, R.; Sommer, T.M. Electric Power Research Inst., Palo Alto, CA (USA). Sep 1989. DOE Contract FC22-87PC79796. (CONF-880326–: 4. symposium on integrated environmental control, Washington, DC (USA), 2-4 Mar 1988). In *Proceedings: Fourth symposium on integrated environmental control.* Order Number DE90000517. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

Emissions of oxides of sulfur and nitrogen are thought to be responsible for acid rain deposition. A large number of existing pre-NSPS electric utility boilers fired with Midwestern and Eastern coals would be affected if acid rain control legislation is promulgated. To allow such boilers to meet potential emissions regulations with fuel flexibility and good operability, cost effective retrofit emissions control technology is required. Gas Reburning-Sorbent Injection (GR-SI), a combination control technology that could be retrofitted to coal fired utility boilers, has the potential to reduce NO_x and SO_2 emissions by 60% and 50%, respectively. Gas reburning consists of the staged introduction of fuel, with coal fired in the main heat release zone, and 15-20% of the heat input added as natural gas in

the downstream reburn zone. This is followed by the burn-out zone where a dry, calcium based sorbent can also be injected for SO_2 pick-up. Alternatively, the sorbent may be injected further downstream in the boiler, or into the flue gas duct between the air heater and the precipitator. A field test project has been initiated as part of the DOE's Clean Coal Technology program to demonstrate GR-SI on three pre-NSPS coal fired utility boilers in Illinois. The Gas Research Institute and the State of Illinois are the other participants in this project. The boilers selected are representative of pre-NSPS design types: one each of tangentially, wall, and cyclone fired units will be tested. Following baseline and optimization testing, the GR-SI technology will be demonstrated in one-year field tests at each host site for a total project duration of fifty-four months.

7506 (ETDE-mf–9761927) **Power station environmental impact monitoring (pilot experimental project).** Brusasca, G.; Elisei, G.; Groppelli, P.; Maini, M.; Marzorati, A.; Tinarelli, G. Ente Nazionale per l'Energia Elettrica, Milan (Italy); Ente Nazionale per l'Energia Elettrica, Milan (Italy). Centro Termica e Nucleare. 1986. 9p. (In Italian). Order Number DE89761927. Available from NTIS (US Sales Only), PC A02/MF A01.

This paper deals with the data acquisition system of the Turbigo (Italy) fossil-fuel power plant. Using mathematical models, environmental impact and meteorological effects are considered, i.e. the use of Gaussian mathematical models for the real time forecasting of environmental impact; emission control in the event of critical meteorological conditions; the use of auto-regressive mathematical models for the forecasting, at least 12 hours in advance, of environmental impact, the possibility of integrating remote sensing instrumentation with the chemical-meteorological monitoring networks of power plants (nuclear and fossil-fuel).

7507 (OH/RD–88-329-K) **Geochemistry of FGD [fuel gas desulphurization] waste by-products.** Zhou, Z.; Dayal, R. Ontario Hydro Research Div., Toronto, ON (Canada). 7 Feb 1989. 25p. (MICROLOG–89-04433). Available from PC Experimental Datasearch Division, Computer Calculations, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

A laboratory study was undertaken to define and evaluate the properties of flue gas desulphurization waste by-products in terms of their chemical and mineralogical characteristics, leaching behaviour, and leachate interactions with clay liner materials. Specifically, the test materials used in this study are based on the limestone/lime injection into the furnace process evaluation test runs carried out at Lakeview Thermal Generating Station. 6 refs., 4 figs., 10 tabs.

7508 (OH/RD–717G620) **Characterizaton of solid wastes from limestone and related sorbent injection processes for acid gas control.** Golomb, A. Ontario Hydro Research Div., Toronto, ON (Canada). Aug 1989. 94p. (CE–02851). Available from Canadian Electrical Association, Research & Development, Suite No. 500, One Westmount Square, Montreal, PQ, CAN H3Z 2P9. Prices: $75.00 NON-MEMBERS; MEMBERS: PRICES UPON REQUEST, FUNDS CAN.

The work described in this report assesses potential problems associated with the handling and disposal of high calcium oxide solid wastes that result from dry limestone and related sorbent addition processes for acid gas control at electric power generating stations. Three such processes that yield high calcium oxide solid wastes are Limestone Injection Multistage Burners (LIMB), Atmospheric Fluidized Bed Combustion (AFBC) and Furnace Sorbent Injection (FSI). A literature review has been carried out to assess the characteristics of the solid wastes derived from utility flue gas SO_2 emission control by LIMB, AFBC and FSI. It was found that, with calcium-based sorbents, and depending on the calcium/sulphur molar ratio and sulphur removal efficiency, all of these processes can yield wastes containing significant bulk concentrations of water-reactive calcium oxide (up to approximately 40 wt%). The exothermic slaking reaction can make handling/disposal of the wastes very difficult. A harmful dust and/or highly alkaline leachate can result. Nevertheless, developmental work, had led to successful full-scale handling and disposal of FSI high calcium oxide wastes. For FSI solid waste samples from Ontario Hydro and Saskatchewan Power, the principal chemical species present have been quantified. Leachate extractions and physical/engineering tests have been done as appropriate on the as received and fixated wastes. Special equipment considered necessary for the handling and disposal of high calcium oxide wastes is recommended, and rough costs are estimated for its full-scale operation. Finally, recommendations are given as to the direction of future research and development. 56 refs., 9 figs., 25tabs.

7509 (SRC–E-906-14-D-86) **Source and ambient sampling relating to the power industry in North America.** Wallace, K.W. Saskatchewan Research Council, Saskatoon, SK (Canada). May 1986. 22p. (MICROLOG–89-03756). Available from PC Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

This report documents the state of environmental monitoring relating to the combusiton of fossil fuels in North America. The basic concepts of manual source sampling for particulated, SO_2, NO_x and in-stack sizing are covered. The principles of operation of continuous emission monitors are discussed. The particulate material, once removed from the source, becomes a problem for ambient sampling. The proposed new standard (PM-10 regulations) and the sampling strategy for measurements are discussed. 3 refs., 8 figs.

2005 Environmental Aspects

Refer also to citation(s) 7679

2006 Economic, Industrial, and Business Aspects

Refer also to citation(s) 7478, 7479

21 NUCLEAR POWER PLANTS

Refer also to citation(s) 8562, 8996

2101 Power Reactors, Nonbreeding, Light-Water Moderated, Boiling Water Cooled

Refer also to citation(s) 7511, 7513, 7555, 7556, 7566, 7574, 7579, 7582, 7583, 7589, 7591, 7884, 7885, 7917, 8942

7510 (PNL-SA–17057) **Feasibility of developing generic piping inservice inspection requirements.** Vo, T.V.; Smith, B.W.; Simonen, F.A. Pacific Northwest Lab., Richland, WA (USA). Apr 1989. 9p. Sponsored by U.S. DOE Nuclear Energy; Nuclear Regulatory Commission. DOE Contract AC06-76RL01830. (CONF-891103–57: Winter meeting of the American Nuclear Society, San Francisco, CA (USA), 26-30 Nov 1989). Order Number DE90003636. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The objectives of a multiyear program entitled Nondestructive Evaluation Reliability for Inservice Inspection of Light Water Reactors (LWR), which is being conducted at Pacific Northwest Laboratory (PNL), are to determine the reliability of current inservice inspections (ISI) of pressure boundary systems and components and to develop recommendations that can ensure a suitably high inspection reliability. The long term objective is to propose changes to Section XI of the American Society of Mechanical Engineer's code for inspection of nuclear power plant components. 2 refs., 1 fig., 1 tab.

2102 Power Reactors, Nonbreeding, Light-Water Moderated, Nonboiling Water Cooled

Refer also to citation(s) 7509, 7524, 7555, 7556, 7574, 7576, 7577, 7579, 7585, 7591, 7884, 7917, 8171, 8942

7511 (BMU–1989-206) **Neutron dosimetry in nuclear power plants with LWR reactors. Final report.** Schriftenreihe Reaktorsicherheit und Strahlenschutz. Ergebnisberichte, Untersuchungen, Studien, Gutachten. Hofmann, B.; Ehlers, K. Bundesministerium

fuer Umwelt, Naturschutz und Reaktorsicherheit, Bonn (Germany, F.R.); Asea Brown Boveri Reaktor G.m.b.H., Mannheim (Germany, F.R.). 1989. 99p. (In German). Contract BMU RS II 2-510 322/463 St.Sch. 1000. Available from Available from GRM Werbeberatung - Werbemittlung - PR, Eggenstein-Leopoldshafen, (Germany, F.R.).

During the nuclear commissioning of the nuclear power station Muelheim-Kaerlich (1986), the neutron radiation fields in the plant compartments of the containment were analyzed. Albedo dosemeters equipped with thermoluminescence and track etch detectors in combination with boron converters were used for personnel monitoring. Results: 1. The neutron fields reach dose rate levels up to 1000 mSv/h at the bulkheads of the main coolant line, in the reactor well and in the reactor cavern sump. The share of neutrons in the total radiation level varies from 10% in the steam generator compartments up to 92% in the reactor well. 2. The effective energy is approx. 100 keV. The share of thermal neutrons in the local dose amounts to approx. 10%. 3. By means of the comparative measurements and different evaluation methods of the albedo dosemeters, it was proved that the rem counters used for the routine control indicated an only slightly ($\simeq$ +20%) elevated dose rate level in the mixed radiation fields of a light water reactor plant and thus are suited to practical radiation protection. 4. The sensitivity of the personnel dosemeters permits the detection of neutrons from 10 muSv onwards. The share of neutrons in the total personal dose amounted to maximally 25%. A constant calibrating factor can be used for the evaluation of the albedo detectors. (orig./HP).

7512 (CONF-891103–53) **Experimental study of the fragmentation and quench behavior of corium melts in water.** Wang, S.K. (Argonne National Lab., IL (USA)); Blomquist, C.A.; Spencer, B.W.; McUmber, L.M.; Schneider, J.P. Argonne National Lab., IL (USA). [1989]. 16p. Sponsored by Nuclear Regulatory Commission. DOE Contract W-31109-ENG-38. From Winter meeting of the American Nuclear Society; San Francisco, CA (USA); 26-30 Nov 1989. Order Number DE90003554. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The interaction of molten core materials with water has been investigated for the pour stream mixing mode. This interaction plays a crucial role during the later stages of in-vessel core melt progression inside a light water reactor such as during the TMI-2 accident. The key issues which arise during the molten core relocation include: (1) the thermal attack and possible damage to the RPV lower head from the impinging molten fuel stream and/or the debris bed, (2) the molten fuel relocation pathways including the effects of redistribution due to core support structure and the reactor lower internals, (3) the quench rate of the molten fuel through the water in the lower plasma, (4) the steam generation and hydrogen generation during the interaction, (5) the transient pressurization of the primary system, and (6) the possibility of a steam explosion. In order to understand these issues, a series of six experiments (designated CCM-1 through -6) was performed in which molten corium passed through a deep pool of water in a long, slender pour stream mode. Results discussed include the transient temperatures and pressures, the rate and magnitude of steam/hydrogen generation, and the posttest debris characteristics. 9 refs., 29 figs.

7513 (CONF-8910222–8) **Embrittlement of the Shippingport reactor shield tank.** Chopra, O.K.; Shack, W.J. Argonne National Lab., IL (USA). Oct 1989. 17p. Sponsored by Nuclear Regulatory Commission. DOE Contract W-31109-ENG-38. From 17. water reactor safety information meeting; Rockville, MD (USA); 23-25 Oct 1989. Order Number DE90003771. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The irradiation embrittlement of the Shippingport neutron tank material has been characterized. Irradiation increases the Charpy transition temperature (CTT) by ~25°C (45°F) and decreases the upper shelf energy. The shift in CTT is not as severe as that observed in the HFIR surveillance specimens. However, the actual value of CTT is higher than that for the HFIR data and the toughness at service temperature is low. The increase in yield stress is 51 MPa (7.4 ksi), which is comparable to the HFIR data. The results also indicate a low impact strength and higher transition temperature for the TL orientation than that for the LT orientation. Some effects of the location across the thickness of the wall are also observed for the LT specimens; CTT is slightly greater for the specimens from the inner region of the wall. The data agree well with results from high-flux test reactors. Annealing studies indicate complete recovery of embrittlement after a 2-h anneal at 400°C. The transition curve for the annealed inner wall specimens is virtually identical to that for the as-received outer wall. The results for weld specimens from the inner and outer walls are also presented. 7 refs., 12 figs.

7514 (EPRI-NP–6679) **Guidebook for maintenance proficiency testing: Final report.** Spiker, V.A. (Anacapa Sciences, Inc., Santa Barbara, CA (USA)); Geiwitz, J. Electric Power Research Inst., Palo Alto, CA (USA); Anacapa Sciences, Inc., Santa Barbara, CA (USA). c Dec 1989. 278p. Sponsored by Electric Power Research Institute. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

This guidebook is designed to be a workbook for the construction of proficiency tests for maintenance personnel in nuclear power plants. Step-by-step details are provided for the definition of organizational needs – who should be tested, on which tasks; decisions about test format – what the test should look like; and calculations of costs and benefits. The primary focus is on the construction of proficiency tests, in particular, written tests of job knowledge and performance tests of job skills. Examples from test-construction activities at two nuclear power plants illustrate the general principles and practical details. Refinement and validation of the tests are discussed thoroughly, and issues and problems that arise in developing and administering a testing program are reviewed. 17 refs., 30 figs., 30 tabs.

7515 (INIS-mf–12029) **Fundamentals in safety engineering of the HTR modular power plant. Final report.** Internationale Atomreaktorbau G.m.b.H. (INTERATOM), Bergisch Gladbach (Germany, F.R.); Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). May 1988. 115p. (In German). Contract BMFT 03IAT205/1. Order Number DE90732321. Available from NTIS (US Sales Only), PC A06/MF A01.

The report describes the results of the investigations on the safety performance of the high-temperature reactor module (HTR module) developed by Interatom. The investigations were conducted for a plant with steam generators for power generation and process steam or long-distance heat supply during operational incidents and design basis accidents. The aim of the HTR module design to keep the maximum environmental load in all cases of disturbance below the values defined in Section 28.3 of the Radiation Protection Ordinance, an aim pursued with the help of appropriate design characteristics, was proved attainable. (orig.).

7516 (IWGFPT–32, pp. 152-159) **New FRAGEMA developments for fuel temperature and fission gas release modelling.** Forat, C. (Fragema, 69 - Lyon (France)). International Atomic Energy Agency, Vienna (Austria). International Working Group on Water Reactor Fuel Performance and Technology. May 1989. (CONF-8809420–: Technical committee on water reactor fuel element computer modelling in steady state, transient and accident conditions, Preston (UK), 18-22 Sep 1988). In *Water reactor fuel element computer modelling in steady state, transient and accident conditions. Proceedings of a technical committee meeting held in Preston, 18-22 September 1988.* Order Number DE90610159. Available from NTIS (US Sales Only), PC A14/MF A01 - OSTI; INIS.

The test results justifying fuel rod design during the seventies and early eighties led to the assumption that the fission gas release phenomenon could become limiting as regards increased discharge burnup. This problem explains the intensive R and D effort pursued by FRAGEMA in cooperation with the CEA for better understanding of the fission gas release phenomenon, especially at high burnups, with the aim of developing a model. Since fission gas release is very strongly dependent on fuel temperature, the new FRAGEMA model was developed for a "Temperature -Fractional Gas Release" rating: Calculations were based both on a best estimate of local fuel temperature with due allowance for pellet restructuring and on degradation of fuel conductivity with crack size and burnup. This part of the model was fitted to experimental measurements of centerline temperature up to 25 GWd/tU. The associated fission gas release model is based on all the observations now being drawn from experimental results. This model simulates the temperature (or power) level as of which release kinetics changes and distinguishes between two ranges: an "athermal" range representative of standard

irradiation conditions, in which the release is practically independent of fuel temperature and motion of atoms and gas bubbles is by recoil or ejection; a "thermal" range, wherein the mechanisms called into play are highly temperature-dependent. The impact of burnup is perceptible at BOL and seems to correspond to "filling" of the grain joints by gas bubbles. For transient conditions a multiplier was fitted, representing the gas transfer time towards the outside. The "Fuel Temperature - Fractional Gas Release" rating was validated at high burnups from measurement - calculation comparisons for a great number of rods, covering a wide range of design parameters and irradiation conditions. (author). 8 refs, 11 figs.

7517 (IWGFPT–32, pp. 228-234) **Modeling of transient fuel behavior in the FREY code and related experimental verification.** Montgomery, R.O. (Anatech International Corp., La Jolla, CA (USA)); Rashid, Y.R.; Zangari, A.J. International Atomic Energy Agency, Vienna (Austria). International Working Group on Water Reactor Fuel Performance and Technology. May 1989. (CONF-8809420–: Technical committee on water reactor fuel element computer modelling in steady state, transient and accident conditions, Preston (UK), 18-22 Sep 1988). In *Water reactor fuel element computer modelling in steady state, transient and accident conditions. Proceedings of a technical committee meeting held in Preston, 18-22 September 1988.* Order Number DE90610159. Available from NTIS (US Sales Only), PC A14/MF A01 - OSTI; INIS.

Analysis and comparison of PWR type transient experiments are presented from FREY verification and validation effort. Methods used to model the fuel, cladding, and coolant geometry are discussed in addition to experiment interpretation. Purpose of this study was to validate the predictive capabilities of the code for severe transient analysis. It was necessary to evaluate and review traditional modeling conventions due to the 3-dimensional effects observed. The experimental results and post-irradiation examinations revealed significant 3-dimensional processes such as circumferential temperature variations and rod bowing as a result of the severe temperature increases observed. In a PWR environment, surface heat fluxes during transient conditions can exceed the critical heat flux (CHF) resulting in departure from nucleate boiling (DNB). Post-DNB operation can result in significant cladding surface temperature increases, loss of cladding strength, and possible fuel rod failure. Therefore, a study was conducted to identify the important factors in 2-dimensional modeling which can be used to estimate the 3-dimensional effects. Traditional axi-symmetric models were supported by detailed r-θ models to better understand the rapidly changing processes present during the experiment. The results of the study indicate that 3-dimensional effects can account for differences of 300 K between predicted and measured results for severe transient analysis of fuel rods subjected to sustained film boiling operation. The study revealed that the geometrical effects of rod bowing on local flow perturbations influences the heat transfer from the fuel rod surface to the coolant. Therefore, the film boiling heat transfer coefficient uncertainties coupled with the circumferential effects can lead to significant deviations in the predicted results for a concentric r-z modeling approach. (author). 14 refs, 8 figs, 1 tab.

7518 (IWGFR–58, pp. 15-21) **Debene status on cavitation in sodium pumps.** Mendte, K. International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

Due to lack of reliable information concerning the material-damaging influence of cavitation on pump impellers, the aim of the DEBENE field was to operate all reactor pumps safely outside the cavitation boundaries. To meet this almost trivial requirement, however, different efforts have been and are being made in the individual breeder reactors. With regard to the KNK reactor primary coolant circuit, pump characteristics prove that the pump complies with the guaranteed design conditions. The construction and testing of a prototype pump to the scale of 1:1 for the SNR-300 reactor and implications for performance of SNR-2 sodium pumps are discussed.

2103 Power Reactors, Nonbreeding, Graphite Moderated

Refer also to citation(s) 6847, 8055, 8419, 8439

7519 (INIS-mf–12024) **Analyses of pebble-bed reactors for the generation of heat for heating purposes. Final report.** Muehlensiep, J.; Fricke, U.; Inhester, K.H.; Kugeler, K.; Phlippen, P.W.; Schmidtlein, P.; Swatoch, R.; Wagner, U. Duisburg Univ. (Gesamthochschule) (Germany, F.R.). Fachgebiet Energietechnik; Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). Oct 1986. 221p. (In German). Contract BMFT 03 UGD 302. Order Number DE90732342. Available from NTIS (US Sales Only), PC A10/MF A01.

Marginal conditions are described for the use of a nuclear power reactor for long-distance heat supply in densely populated areas. For the design of the high-temperature heat generating reactor, plant components and possible arrangements are analyzed with consideration to safety and costs. System sizes are reasonably chosen on the basis of analyzed parameters, the paramount design goal being to adequately retain the fission products in the coated particles of the fuel elements, in anticipation of probable accidents. With the help of the data record obtained, a system is designed with a cuboid-shaped core as its characteristic feature; the advantage of the core consists in the fact that it quickly discharges the after-heat outwards even in case of a hypothetical accident. Due to the core shape, it is possible to install heat-exchanging components near the core, and to place the safety rods where they can be very effective in reflector borings. (orig./HP). With 29 refs., 39 tabs., 122 figs.

7520 (INIS-mf–12037) **Annual report 1987. Activities: Accompanying planning work for the PNP R and D programme 1985/1988.** Gesellschaft fuer Hochtemperaturreaktor-Technik m.b.H., Bergisch Gladbach (Germany, F.R.). 1 Feb 1988. 49p. (In German). Contract BMFT PTH 03 IAT 306 2. Order Number DE90732698. Available from NTIS (US Sales Only), PC A03/MF A01.

As there is high materials utilization in the heat exchanger structures in the temperature range above 950^{0}C, the temperature and velocity distribution must be equalized as far as possible. Specified inlet conditions for the helical He/He heat exchanger which in this respect puts the highest requirements, allow a temperature gradient of ΔT=+15/-30 K, and a velocity range of V=±10%. Temperature equalization is to be achieved by suitable design measures, for equalization over the pathway from core bottom to hot gas header, through the hot gas pipe and the flow conditioning device before the heat exchanger (temperature gradient at core outlet to be ΔT=±120 K). The experimental results concerning the flattening of radial temperature gradients of the coolant in crossing flow channels of the core bottom have shown that re-partitioning processes in the knots do not completely abolish temperature peaks in the channels. Improved mixing may be achieved in the hot gas header below the core bottom, and possibly also in the hot gas pipe. Experiments have been planned therefore that were to study a complete section of the core bottom (15^0 section) in radial and vertical direction, together with the hot gas header below, at original scale, in order to verify the global mixing effect. (orig.).

7521 (INIS-mf–12038) **Semi-annual report on the second half of the year 1986. Activities: Accompanying planning work for the PNP R and D programme 1985/1986.** Gesellschaft fuer Hochtemperaturreaktor-Technik m.b.H., Bergisch Gladbach (Germany, F.R.). [1989]. 112p. (In German). Contract BMFT PTH 03 IAT 306 2. Order Number DE90732697. Available from NTIS (US Sales Only), PC A06/MF A01.

As there is high materials utilization in the heat-exchanger structures in the temperature range above 950^{0}C, the temperature and velocity distribution must be equalized as far as possible. Specified inlet conditions for the helical He/He heat exchanger which in this respect puts the highest requirements, allow a temperature gradient of ΔT=+15/-30 K, and a velocity range of V=±10%. The required temperature equalization is to be achieved by suitable design measures, for equalization over the pathway from core bottom to hot gas header, through the hot gas pipe and the flow conditioning device before the heat exchanger (temperature gradient at core outlet ΔT=±120 K). Experiments have to be made at the core bottom stone and the integrating structures in order to give proof of the

realisation of the required equalization. The experiments will be accompanied by theoretical investigations. (orig./GL).

7522 (INIS-mf-12039) **Semi-annual report on the first half of the year 1988. Activities: Accompanying planning work for the PNP R and D programme 1985/1988.** Gesellschaft fuer Hochtemperaturreaktor-Technik m.b.H., Bergisch Gladbach (Germany, F.R.). 1 Aug 1988. 31p. (In German). Contract BMFT PTH 03 IAT 306 2. Order Number DE90732696. Available from NTIS (US Sales Only), PC A03/MF A01.

The re-calculation of the Balcke-Duerr experiments for testing of the URKO variant of the He/He heat exchangers with the COMMIX code has shown that particularly for the case of decreasing throughput in the heat exchanger, information on the thermohydraulics alone (COMMIX) does not suffice for an accurate analysis of component stresses. In addition to the 3-dimensional thermohydraulic processes, the 3-dimensional heat transfer problems are of decisive significance (especially radiative heat transfer). The code version COMMIX/STINT developed for combined analysis was to be validated by experimental recalculation in the period under review. Selected pebble-bed experimental cores (KFA) have been recalculated for validation of the code version COMMIX (3D convection)/ STINT (3D heat transfer and radiative transfer). These experiments simulate the operating status 'long-term hot operation' at unstable temperature stratification (hot structures below/cold structures above). (orig./GL).

7523 (Juel-2230) **Experiments with heat exchanger tubes with intermediate circuit - theory and practice.** Burgholz, L.M. Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Inst. fuer Reaktorentwicklung; Technische Hochschule Aachen (Germany, F.R.). Aug 1988. 128p. (In German). Order Number DE90732348. Available from NTIS (US Sales Only), PC A07/MF A01.

Hydrogen permeation by heat-exchanging components is a problem of PNP plants (prototype plants for nuclear process heat) for which solutions are still being sought. In this study, the efficiency of an intermediate cycle for the reduction of permeation streams is examined on the basis of adjustable parameters such as speed, dampness of sweep gas, efficiency of an ancillary gas purification installation. The velocity constants determining the permeation were quantified for the assessment of the partial tritium pressures which developed in the presence of protium, and the influence of the build-up of counter-pressures was examined. A theoretical approach is confirmed by means of measurements. In this respect, surface effects play a great role for tritium. In experiments for embedding tritium in water vapour, the HTO/HT ratio almost becomes exactly equal to the H_2O/H_2 ratio. (RB).

7524 (Juel-Spez-514(v.2)) **Statistical investigations of the failure behaviour of components in the AVR experimental nuclear power plant. Vol. 2. Failure parameters of helium valves; application and interpretation of various statistical methods.** Meyna, A.; Mock, R.; Tietze, A. (Wuppertal Univ. (Gesamthochschule) (Germany, F.R.)); Hennings, W. (ed.). Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Inst. fuer Nukleare Sicherheitsforschung. Aug 1989. 142p. (In German). Order Number DE90732553. Available from NTIS (US Sales Only), PC A07/MF A01.

From operational records of the years 1977 to 1986, service life distributions of helium valves in gas circuits of the AVR were determined. Results are constant failure rates in the range from 3 to $6x10^{-6}$/h and, for some populations, indications of time dependent failure rates. Nonparametric methods showed only limited efficiency. For a Bayesian approach the necessary prior information was missing. Furthermore, the main failure causes could be determined. (orig./HP).

7525 (ORNL/FTR-3477) **[HTGR research and licensing]: Foreign trip report, November 6, 1989–November 18, 1989.** Ball, S.J. Oak Ridge National Lab., TN (USA). 4 Dec 1989. 19p. Sponsored by Nuclear Regulatory Commission. DOE Contract AC05-84OR21400. Order Number DE90003994. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The traveler was asked by the US Nuclear Regulatory Commission (NRC/RES) to travel with Dr. Peter M. Williams, NRC MHTGR Project Manager, to assist in obtaining information from researchers and licensing authorities in the United Kingdom and Western Europe relevant to the NRC's ongoing evaluation of the DOE Modular HTGR (MHTGR) research program plan and licensability concerns. The NRC- sponsored ORNL program for HTGR safety reviews, of which the traveler is manager, has made significant use of foreign resources in conducting safety research, developing independent safety analysis capabilities, and assisting NRC in preparation of safety analysis reports. The additional information derived on this trip from detailed discussions with researchers and licensing authorities, laboratory and reactor site tours, and literature received will be very valuable in carrying out the NRC program. Specific information and insights were obtained in the areas of primary system component performance, reactor operations, control and safety system design and performance, fuel performance and fission product transport, safety analysis, heat transfer and fluid flow, reactor physics, advanced designs, and licensing criteria and methods. 28 refs.

7526 **Mechanical properties of alloy steels in molten sodium-potassium nitrate salts.** Goods, S.H. (Sandia National Laboratories, Livermore, CA (USA)). *TMS (The Metallurgical Society) Paper Selection (USA)*, 56: 49 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

A series of slow strain rate experiments have been performed in order to determine the influence of 60 weight percent $NaNo_3$-40 weight percent KNO_3 salt environment on the tensile properties of several Fe based containment alloys. The results of these tests indicated that at 600 C high Cr austenitic stainless steels suffered no measurable degradation in their mechanical properties (tensile strength and ductility) when compared to air exposed control specimens. Lower alloy steels such as 2.25 Cr - 1 Mo did, however, suffer a significant loss in ductility when exposed to this environment at 450 and 525 C. Alloy strength was also markedly affected as the result of salt exposure. These results along with the influence of deformation on the structure of the oxide films formed in the salt environment are discussed.

2104 Power Reactors, Nonbreeding, Otherwise Moderated or Unmoderated

Refer also to citation(s) 7578

2105 Power Reactors, Breeding

Refer also to citation(s) 6956, 7547, 7553, 7597, 7914

7527 (CONF-891103–52) **SASSYS-1 balance-of-plant component models for an integrated plant response.** Ku, J.-Y. Argonne National Lab., IL (USA). [1989]. 17p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract W-31109-ENG-38. From Winter meeting of the American Nuclear Society; San Francisco, CA (USA); 26-30 Nov 1989. Order Number DE90003549. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Models of power plant heat transfer components and rotating machinery have been added to the balance-of-plant model in the SASSYS-1 liquid metal reactor systems analysis code. This work is part of a continuing effort in plant network simulation based on the general mathematical models developed. The models described in this paper extend the scope of the balance-of-plant model to handle non-adiabatic conditions along flow paths. While the mass and momentum equations remain the same, the energy equation now contains a heat source term due to energy transfer across the flow boundary or to work done through a shaft. The heat source term is treated fully explicitly. In addition, the equation of state is rewritten in terms of the quality and separate parameters for each phase. The models are simple enough to run quickly, yet include sufficient detail of dominant plant component characteristics to provide accurate results. 5 refs., 16 figs., 2 tabs.

7528 (CONF-891103–55) **COMMIX analysis of four constant flow thermal upramp experiments performed in a thermal hydraulic model of an advanced LMR.** Yarlagadda, B.S. Argonne National Lab., IL (USA). Apr 1989. 16p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract W-31109-ENG-38. From Winter meeting of the American Nuclear Society; San Francisco, CA

(USA); 26-30 Nov 1989. Order Number DE90003567. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The three-dimensional thermal hydraulics computer code COMMIX-1AR was used to analyze four constant flow thermal upramp experiments performed in the thermal hydraulic model of an advanced LMR. An objective of these analyses was the validation of COMMIX-1AR for buoyancy affected flows. The COMMIX calculated temperature histories of some thermocouples in the model were compared with the corresponding measured data. The conclusions of this work are presented. 3 refs., 5 figs.

7529 (IKE–2-82) **Two-phase pressure drop and heat transfer of sodium at forced convection.** Grieb, G. Stuttgart Univ. (Germany, F.R.). Inst. fuer Kernenergetik und Energiesysteme. Apr 1989. 141p. (In German). Order Number DE90732509. Available from NTIS (US Sales Only), PC A07/MF A01.

Experiments with sodium for the two-phase pressure drop in vertical tubes with upward flow (internal diameters 6 and 9 mm) performed at the Joint Research Centre (JRC) of the European Communities in Ispra, Italy, and at the Nuclear Research Centre in Karlsruhe (KfK) were evaluated and analysed. Furthermore, experiments for the single-phase and two-phase heat transfer in the grid spaced twelve-rod bundle (p_s/d =1.3, rod diameter 8 mm) with flow in axial direction performed at the JRC were evaluated and analysed. The pressure drop measurements were carried out at moderate to high mass flow rates (30 to 4500 kg/(m^2s)) and at moderate pressures (50 to 300 kPa, density ratio rho_f/rho_g = 950 to 5400). The measurements for the single-phase heat transfer at high heat fluxes (0.16 to 1.6 MW/m^2) were carried out in the Reynolds number region (3100 < Re < 85 000). The measurements for the two-phase heat transfer were made at moderate mass flow rates (70 to 770 kg/(m^2s)) and at high heat fluxes (0.46 to 1.6 MW/m^2) within the temperature range from 870 to 970^{0}C. For the subsequent calculation of the experiments relating to the two-phase pressure drop a computer program was developed, which is based on the so-called slip model. It requires a friction pressure loss correlation and a slip correlation. The tested correlations were not suitable for describing the experimental measurements. Accordingly, simplified equations of momentum were used to develop a new slip correlation for the case of annular flow together with the annular-mist flow, the most important two-phase flow regimes for sodium in the measurement range. After the inception of the entrainment - transition from the annular flow to the annular-mist flow - an even larger fraction of liquid enters the vapour core in the form of droplets, as the vapour quality increases.

7530 (INIS-SU–133/A, pp. 26-28) **Shape change of hexagonal fuel assembly cans in fast power reactors conditioned with irradiation creep at heavy radiation exposures.** Gann, V.V. (AN Ukrainskoj SSR, Kharkov (Ukrainian SSR). Fiziko-Tekhnicheskij Inst.); Gomov, O.I. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

Voprosy atomnoj nauki i tekhniki.; v. 4(46).

A method for calculating the shape change of fuel assembly cans in fast power reactors taking into account elastic deformations, shift, as well as the effect of the occurring longitudinal force on the bending momentum, is proposed. The significance of earlier unaccounted for factors for estimations of the hexahedron behaviour at higher irradiation doses in some fast reactors is shown. 6 refs.; 1 fig.

7531 (IWGFR–58, pp. 22-28) **Activities of cavitation studies and R&D works of sodium pumps in Japan.** Kambe, M.; Mori, K.; Hayashi, Y. International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

PNC is now performing design studies of large FBR, making the best use of past experiences form JOYO, MONJU and related research and development efforts (R & Ds), aiming at future effective and sound development of FBR technology and at the appropriate cooperation with utilities and manufacturers. In this paper the activities of cavitation studies and R&D works of sodium pumps as well as general review of the FBR development are presented. Such activities are concentrated on the following items: (1) In-sodium and in-water cavitation tests of JOYO primary and secondary pumps as well as cavitation damage inspection after 30 000 hours of operation. (2) In-water cavitation test of subscale mock-up pumps for MONJU. (3) In-water cavitation test of subscale mock-up pump for large FBR including incipient cavitation bubble observation. (4) Cavitation tests of FLIPs (600 1/min and 1100 1/min) and ALIP (400 1/min). (5) Approach to define more advanced cavitation criteria for electromagnetic pumps instead of applying Thoma's dimensionless parameter. In view of this, cavitation tests of a FLIP and its duct models with sodium and model fluid are conducted. (6) Studies on the impeller type optimization for large FBRs: single suction, double suction and inducer type are comprised. (7) Design studies of single suction and double suction pumps for large FBRs.

7532 (IWGFR–58, pp. 29-40) **Cavitation in pumps: Research and development in France.** Courbiere, P.; Lecoz, P. International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

The current lack of information concerning sodium pump cavitation has two important consequences: conservative pump design, and restricted operating ranges for reactor pumps. Until now, the following criteria were used for water testing of pump mockups (NPSH = net positive suction head): $(NPSH)_i$: appearance of the first bubble in the flow steam at the impeller vanes. $(NPSH)_i$': appearance of the first figure considered unstable and dangerous. $(NPSH)_d$: initial drop in performance. $(NPSH)_{CX}$: X% loss of head. $(NPSH)_g$: breakdown of performance characteristics. The criterion adopted for designing the PHENIX and SUPER PHENIX 1 primary sodium pumps was: $(NPSH)_i$' + 2 m. The last three criteria mentioned correspond to advanced cavitation conditions and cannot be used in reactors, while the first two are only visual criteria that cannot be implemented in sodium. In order to define a criterion better suited to sodium applications, a joint research and test program was conducted by the CEA and Jeumont-Schneider involving water tests on a SUPER PHENIX 1 pump mockup and on the actual SUPER PHENIX 1 primary sodium pumps.

7533 (IWGFR–58, pp. 41-43) **IAEA specilists meeting on sodium cavitation.** International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

Studies and experiences carried out in Italy on cavitation in sodium can be splitted in two groups: cavitation in sodium pumps and cavitation in others components or parts (such as foot of fuel elements, valves, etc). Considering the good agreement between cavitation similitude in water and in sodium the authors deem the similitude in water enough to design and to test sodium pumps. The general approach of cavitation in pumps design and testing is discussed.

7534 (IWGFR–58, pp. 44-65) **The design and testing of sodium pumps in the UK to meet the CDFR cavitation criteria.** Preece, G.E.; Macleod, I.D.; Wilkinson, D. International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number

DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

A primary objective in the design of the sodium pumps for the UK Commercial Demonstration Fast Reactor has been to avoid cavitation during normal operation. This requirement arises from the need to avoid blade erosion and also, in the case of the Primary Sodium Pumps (PSP), the generation of cavitation noise which might otherwise interfere with instrumentation installed to detect noise of boiling in the core. This paper outlines the approach adopted to achieve a pump design with good cavitation performance and the programme of model testing carried out in a water loop to establish the cavitation boundaries for incipient cavitation of selected designs using both visual and acoustic techniques.

7535 (IWGFR–58, pp. 66-73) **Design of PFBR sodium pumps and their cavitation performance criteria.** Kale, R.D. (Reactor Research Centre, Tamilnadu (India)); Rao, A.S.L.K. International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

The Prototype Fast Breeder Reactor (PFBR) currently under design in India is a 500 MWe sodium cooled reactor plant of pool design. The reactor will have four heat transport loops in the primary as well as the secondary. The total primary coolant flow is expected to be 32 000 cubic metres/hr and the total pressure drop in the circuit within 80 mlc. Primary sodium will be circulated by four pumps immersed in the cold sodium pool (400°C) and supported from the roof structure. This paper discusses the design of the primary sodium pumps with particular reference to cavitation performance requirements. An outline of the experimental programme for the hydraulic development is also given.

7536 (IWGFR–58, pp. 74-92) **Study on cavitation in centrifugal sodium pumps for FBTR and PFBR.** Rao, A.S.L.K. (Reactor Research Centre, Tamil-nadu (India)); Prabhakar, R.; Prakash, V.; Paranjpe, S.R. International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

Fast Breeder Test Reactor (FBTR) which is expected to become critical shortly is a loop type reactor of 40 MW thermal capacity and has two primary and two secondary centrifugal pumps for heat removal. During the initial periods of reactor operation, the steam generator is bypassed and the secondary sodium pumps are required to operated at flows less than that at best efficiency point. This paper deals with the cavitation problems associated with operation at partial flows, theoretical estimations and experimental cavitation measurements carried out on FBTR secondary sodium pumps. These investigations revealed that operation of FBTR pumps at this off-design condition is free from cavitation damage. Cavitation experiments on a model pump for the development of large sodium pumps for a 500 MWe Prototype Fast Breeder Reactor (PFBR) are described in this paper.

7537 (IWGFR–58, pp. 93-109) **Cavitation tests for JOYO primary and secondary main circulating pumps.** Kambe, M; Kamei, M. International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

The paper outlines the development undertaken to determine the cavitation characteristics of mechanical sodium pumps. Test programmes on cavitation in sodium and in water have been undertaken to predict the condition of cavitation onset in sodium from measurements on water mock-up. Test data show close concordance between the cavitation threshold values obtained in water and those obtained in sodium.

7538 (IWGFR–58, pp. 110-125) **Design of SPX-2 secondary pump.** Valentini, S.; Chessa, A. International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

All LMFBR secondary pumps in France and Italy (Phenix, Superphenix, PEC) are centrifugal and much similar in design. In some cases, as for the Phenix and PEC pumps, the hydrostatic bearing is mounted on top of the impeller, while the hydrostatic bearings of the Superphenix pumps are located below the impeller, inside the diffusor. The advantage of these pumps lies in the fact that their design and general concept have been thoroughly tried out in the operation of the above mentioned reactors as well as in some experimental sodium circuits, but their considerable dimensions and weight are a drawback from economic viewpoint. For this reason studies were performed to improve design of secondary pumps and to find more economic solutions. The results of the studies, calculations and experimental tests performed on the mixed-flow secondary pump permit to draw the following conclusions: The pump concept is rather simple; dimensions and weight are reduced. Pump hydraulics studied at theoretical level and model tested are such as to ensure the required performances with satisfactory efficiency. The stress level in the pump is within allowable limits. Materials and technology to use for pump manufacture are similar to those used for the construction of sodium pumps for other reactors (SPX-1, PEC). The pump can be used as a secondary pump for SPX-2 or other reactor types having similar operating features.

7539 (IWGFR–58, pp. 126-145) **Cavitation erosion in a 400°C sodium flow.** Courbiere, P. (CEA, Saint Paul Lez Durance (France)). International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

This paper presents the results of cavitation erosion tests conducted in the Cavitation Tunnel at the Cadarache Nuclear Research Center. The CANASTA system was used for acoustic monitoring of cavitation noise during the experiments. Comparative results are also presented for sodium and water tests.

7540 (IWGFR–58, pp. 146-168) **Prediction of EMP cavitation threshold from other than sodium testing.** Kambe, M.; Kamei, M. International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

An experimental study has been performed to predict the cavitation threshold of electromagnetic pumps from measurements on test models using water and alcohol. Cavitation tests were carried out using water and alcohol test loop on subscale ducts of transparent acrylic resin with reference to an actual pump. These data were compared to those obtained from the in-sodium tests on the actual pump. The investigation revealed that the value of Thoma's dimensionless parameter: σ applied to the test model for water and alcohol is quite higher than that of corresponding σ on the actual pump. To minimize the incipient cavitation safety margin, more accurate prediction must be required. In view of this, the authors

proposed the dimensionless parameter: $\sigma_T = \sigma / \overline{We}$ where $\overline{We}$ denotes the Weber number. This parameter was confirmed to predict the cavitation threshold of electromagnetic pumps with much accuracy than ever before. It can also be adopted to predict cavitation threshold of other FBR components.

7541 (IWGFR–58, pp. 169-201) **Acoustic surveillance as a detection method for cavitation in pumps.** Foerster, K. International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

Within the process of pump design and optimization, cavitation studies are of great importance. The calculation of cavitation numbers or the experimental determination of cavitation limits, such as the beginning head loss or the increase of mechanical vibrations in the system, are used for the achievement of trouble free pump operation. Since the strong acoustic effects of cavitation are well known, also noise measurements have proved as a good means for controlling this hydrodynamic process in a liquid system. The advantages of this method are that it is very sensitive, so that the first inception of cavitation can be detected, and further that the measurement normally can be performed from the outside of the system, without direct access to the fluid. On the other hand, one has to take into account that in most cases noise measurements do not indicate the dangerousness of a cavitating process, for instance in terms of erosion weight loss. However, since acoustics yields a lot of useful information, it is very often used for optimization purposes. Especially the recent development of very sensitive sound-transducers covering a wide frequency range favors sound measurements to be used for investigating high frequency cavitation effects. As an example the hydraulic improvement of an EM-Pump by means of cavitation noise measurements is discussed.

7542 (IWGFR–58, pp. 202-224) **Super Phenix 1 sodium pumps: Cavitation and scale effects.** Courbiere, P. (CEA, Saint Paul Lez Durance (France)). International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

This paper first presents the results of water tests of the SUPER PHENIX primary pumps and the one-fourth scale mockup. An acoustic technique for detecting cavitation is discussed together with the results of reduced scale tests, and an acoustic cavitation criterion is specified. The initial sodium test results for the SUPER PHENIX pumps are then presented.

7543 (IWGFR–58, pp. 225-240) **Design consideration of NPSH margin for primary and secondary pump of a FBR plant.** Mori, K.; Hayashi, Y.; Kambe, M. International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

The paper explains a design philosophy for cavitation of primary and secondary pumps for a FBR plant. A net positive suction head (NPSH) margin for pumps are determined, keeping suitable suction specific speed which prevents substantial cavitation problems. The required NPSH which is defined as 3% head drop point is confirmed by water tests of full mock-up and sub-scale models. On the other hand expected NPSH margin under operation will be much higher considering the margin of system design, so potential cavitation problems are considered to be more diminished.

7544 (IWGFR–58, pp. 241-278) **Pump cavitation and inducer design.** Heslenfeld, M.W.; de Hes, M. International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

The experimental program for the design of the inducer as an integral part of the sodium pump of the SNR-300 reactor is described. After an introduction, the SNR-300 power plant is briefly described, as are the following: sodium pump development for the SNR-300, sodium pump development for the follow-up line, inducer design philosophy, inducer model design and experiments, cavitation and acoustic noise measurements, and application for the SNR-2 pool type LMFBR.

7545 (IWGFR–58, pp. 279-287) **Inducer pumps for liquid metal reactor plants.** Jackson, E.D. (Rockwell International, Canoga Park, CA (USA)). International Atomic Energy Agency, Vienna (Austria). International Working Group on Fast Reactors. 1985. (CONF-8510488–: Specialists' meeting on cavitation criteria for designing mechanisms working in sodium application to pumps, Bensberg (Germany, F.R.), 28-29 Oct 1985). In *Cavitation criteria for designing mechanisms working in sodium application to pumps: Specialists' meeting, Summary report.* Order Number DE88900331. Available from NTIS (US Sales Only), PC A13/MF A01.

Pumps proposed for liquid metal reactor plants typically use centrifugal impellers as the rotating element and are required to maintain a relatively low speed to keep the suction specific speed low enough to operate at the available net positive suction head (NPSH) and to avoid cavitation damage. These low speeds of operation require that the pump diameter increase and/or multiple stages be used to achieve the design head. This frequently results in a large, heavy, complex pump design. In addition, the low speed results in a larger drive motor size so that the resultant penalty to the plant designer is multiplied. The heavier pump can also result in further complications as, e.g., the difficulty in maintaining the first critical speed sufficiently above the pump operating range to provide margin for rotordynamic stability. To overcome some of these disadvantages, Rockwell International has proposed the use of inducer pumps for Liquid Metal Fast Breeder Reactor (LMFBR) plants. This paper discusses some of the advantages of the inducer pump and the development history of designing and testing these pumps both in water and sodium.

2106 Power Reactors, Auxiliary, Mobile, Package, and Transportable

Refer also to citation(s) 7933, 8203

7546 (CONF-900109–5) **Tuned-circuit Johnson noise thermometry.** Roberts, M.J. (Tennessee Univ., Knoxville, TN (USA)); Blalock, T.V.; Shepard, R.L. Oak Ridge National Lab., TN (USA). [1989]. 6p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. From 7. symposium on space nuclear power systems; Albuquerque, NM (USA); 7-11 Jan 1990. Order Number DE89016221. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Three tuned circuits that can be used in Johnson noise thermometry have been analyzed; series resistance-inductance-capacitance (RLC), parallel RLC, and transformer coupled. Tuned circuits allow the temperature of the sensor to be determined by a single noise voltage, which is ideally independent of the resistance of the sensor, thereby reducing the complexity of temperature-measuring systems for space applications. Direct-coupled and transformer-coupled tuned circuits may offer advantage to the SP-100 system designer interfacing with data systems. A study was performed to establish whether the advantages of the ideal tuned circuits would be obtained with real, lossy inductive components and would provide a measurement system independent of aging and temperature effects on sensor resistance. Theoretical mean-squared output voltage dependence on sensor temperature and resistance, output

capacitor value, and inductor temperature and resistance are derived for the series and parallel RLC cases. It is shown for tuned circuits using lossless inductors that the mean squared voltage is kT_R/C, where T_R is the sensor temperature and C is the capacitance of the capacitor. For lossy inductors and transformers, the mean-squared capacitor voltage is a function of sensor resistance, which may change in an unknown manner during an extended mission. Experiments were performed using a low-loss magnetic core as the core material of an inductor and also of a transformer. These results show that the effects of core loss on temperature accuracy are roughly the same in both cases. Experiments also show that for a sensor resistance of 100Ω at 1375K and for appropriate choices of inductance and capacitance values, the temperature measurement error due to an unknown sensor resistance change is in the range of 0.3 to 1 K/Ω, depending on the circuit used. 3 refs., 8 figs.

7547 (CONF-900109–12) **Dynamics analyses of space power systems using the salt code.** Geyer, H.K. (Argonne National Lab., IL (USA)); Bhattacharyya, S.K.; Hanan, N.A.; Livingston, J.M. Argonne National Lab., IL (USA). [1989]. 10p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract W-31109-ENG-38. From 7. symposium on space nuclear power systems; Albuquerque, NM (USA); 7-11 Jan 1990. Order Number DE90002274. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The dynamic behavior of large space power systems has been identified as a significant technical issue. To date several analyses of reactor kinetics have been reported in the literature, but there have been few (if any) studies of the dynamic response of the entire space power system. The problem is complex and required analytical methods are not generally available. Furthermore, given the conceptual state of current MMW space power systems designs, dynamic models of components are not generally available. We have used the SALT code to perform preliminary analyses of the startup and shutdown transients of several proposed MMW system designs. In this paper we will provide a description of the code methodology and present results of the analyses performed for the NERVA derivative reactor (NDR) system. 3 refs., 3 figs.

7548 (CONF-900109–13) **The onset of boiling of the liquid alkali metals.** Holtz, R.E.; Lottes, P.A. Argonne National Lab., IL (USA). [1989]. 7p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract W-31109-ENG-38. From 7. symposium on space nuclear power systems; Albuquerque, NM (USA); 7-11 Jan 1990. Order Number DE90002276. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Studies pertinent to the liquid superheat required to initiate boiling and the subsequent behavior of the two-phase fluid have been conducted for many years. Knowledge of the incipient-boiling superheats is important because of the proposed use of liquid metals as reactor coolants, Rankine cycle working fluids, and heat-rejection fluids in space energy-conversion systems. Some of the parameters that have been postulated to influence the incipient boiling superheats and the subsequent two-phase flow behavior of the alkali metals include the system pressure, the pressure-temperature-time history, heat flux, liquid purity, dissolved gas content, surface condition, nuclear radiation, heating method, length of time of operation (for example, aging), liquid velocity, and the approach to boiling. The prediction of incipient-boiling superheats is complex, and the influence of some of these parameters needs additional clarification. 6 refs., 3 figs.

7549 (LA-UR–89-1952) **Low risk low power heat pipe/ thermoelectric space power supply.** Ranken, W.A. (Los Alamos National Lab., NM (USA)); Drivas, P.J.; Raag, V. Los Alamos National Lab., NM (USA). 1989. 9p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract W-7405-ENG-36. (CONF-900109–2: 7. symposium on space nuclear power systems, Albuquerque, NM (USA), 7-11 Jan 1990). Order Number DE89014817. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

This paper discusses guidelines directed towards achieving low mass reactor power systems and describes a system that combines features – a number borrowed from earlier concepts – that reduce mass at the same time as they reduce development risk and increase reliability.

7550 (LA-UR–89-1982) **Model-reference adaptive control applied to load-following of a space-nuclear power system.** Metzger, J.D. (Los Alamos National Lab., NM (USA)); El-Genk, M.S.; Parlos, A.G. Los Alamos National Lab., NM (USA). [1989]. 8p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-36. (CONF-900109–3: 7. symposium on space nuclear power systems, Albuquerque, NM (USA), 7-11 Jan 1990). Order Number DE89014561. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Nuclear power systems are presently being investigated as an alternative for both commercial and military space power systems because of their projected longevity of 7 to 10 years, their mass advantage over other space power sources at powers above approximately 25 kW_e, and their ability to operate without direct illumination from the sun. These space-nuclear power systems are being designed to supply from tens of kilowatts to multimegawatts of power for continuous operation of seven years and more. Space-nuclear power systems designs that meet these requirements will not be available for refueling or maintenance during their lifetime. To ensure that the space-nuclear power system will operate safely and will respond in a predictable and desired manner, the design of the system's controller must account for changes in the system parameters over its lifetime. This paper applies model-reference adaptive control to an increase in the power demand by the load. A model-reference adaptive controller will force the actual space-nuclear power system to follow the predictable and desired response of a reference model, despite changes in the actual system's operating parameters. Included in this paper are the model-reference adaptive control algorithm, the description of the computer simulation of a space-nuclear power system and the reference model, and results that demonstrate the application of model-reference adaptive control to a change in the load power demand. The results demonstrate that model-reference adaptive control can ensure the transient response of the system despite differences between the design of the system and the as-built system as well as for variations in the systems parameters. 5 refs., 3 figs.

7551 (LA-UR–89-2633) **High-temperature, deployable, membrane heat-pipe radiator element; demonstration and status.** Trujillo, V.L.; Keddy, E.S.; Merrigan, M.A. Los Alamos National Lab., NM (USA). [1989]. 6p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract W-7405-ENG-36. (CONF-900109–7: 7. symposium on space nuclear power systems, Albuquerque, NM (USA), 7-11 Jan 1990). Order Number DE90000612. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Performance tests of a high-temperature, deployable, membrane heat pipe have been conducted. This system is intended for use in thermal rejection systems for space nuclear power plants. Because current developmental programs for space nuclear power require heat rejection systems in the 2 to 100-megawatt range, development of lightweight, large-area, heat rejection radiators with operating temperatures of greater than 600 K is being investigated. Heat-pipe radiators are potentially the lightest-weight closed-loop systems available in this power and temperature range. Current state-of-the-art radiator designs provide a specific mass in the range of 5 to 20 kg/m^2. Membrane heat-pipe designs using alkali metals as the working fluids and metal foil for containment, offer the potential for a specific mass of about 1.8 kg/m^2 and a mass-to-power ratio of approximately 0.04 kg/kW at 1000 K. Because the membrane heat pipes are flexible, the radiator may be rolled up for compact storage and shielding between operating periods. Passive deployment is achieved by the internal pressure developed as the working fluid is brought to operating temperature and thus requires no linkages, actuators, or special-purpose elements. Upon deployment, the high-temperature radiator unrolls, like a party favor, to a fully extended position. 5 refs.

7552 (LA-UR–89-3363) **Niobium 1% zirconium/potassium and titanium/potassium life-test heat pipe design and testing.** Sena, J.T.; Merrigan, M.A. Los Alamos National Lab., NM (USA). [1989]. 7p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract W-7405-ENG-36. (CONF-900109–11: 7. symposium on space nuclear power systems, Albuquerque, NM (USA), 7-11 Jan 1990). Order Number DE90002430. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Experimental lifetime performance studies currently in progress use Niobium-1% Zirconium (Nb-1Zr) and Titanium (Ti) heat pipes with potassium (K) as the working fluid. A heat pipe life-test matrix has been developed for testing the heat pipes. Because the corrosion rates in alkali metal heat pipes are affected by temperature and working fluid evaporation flux, the variable parameters of the experimental matrix are established as steady operating temperature and input heat flux density. Total impurity inventory is a factor in corrosion rate so impurity levels are being evaluated in the heat pipe materials before and after testing. Eight Nb-1Zr/K heat pipes were designed, fabricated, and tested. Two of the heat pipes have completed testing whereas the other six are currently in test. These are gravity-assist heat pipes operating in a reflux mode. The heat pipes are tested by sets, one set of two and two sets of three heat pipes. Three Ti/K heat pipes are also in life test. These heat pipes are tested as a set in a horizontal position in a capillary pumped annular flow mode. Each of the heat pipes is encapsulated in a quartz vacuum container with a water calorimeter over the vacuum container for power throughput measurements. Thermocouples are attached to the heat pipes for measuring temperature. Heat input to the heat pipes is via an rf coil. The heat pipes are operating at between 800 and 900 K, with heat input fluxes of 13.8 to 30 W/sq cm. Of the Nb-1Zr/K heat pipes, two of the heat pipes have been in operation for 14,000 hours, three over 10,000 hours, and three over 7,000 hours. The Ti/K heat pipes have been in operation for 1,266 hours. 5 refs., 4 figs., 1 tab.

7553 (LA-UR-89-3365) **Radial heat flux limits in potassium heat pipes: An experimental and analytical investigation.** Woloshun, K.A.; Sena, J.T.; Keddy, E.S.; Merrigan, M.A. Los Alamos National Lab., NM (USA). [1989]. 6p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract W-7405-ENG-36. (CONF-900109–14: 7. symposium on space nuclear power systems, Albuquerque, NM (USA), 7-11 Jan 1990). Order Number DE90002655. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

A radial flux limit of 147 W/cm^2 at the wetted inner tube wall has been demonstrated with a Nb-1%Zr/K heat pipe, a flux 5 times greater than the previously accepted safe design level of 25-30 W/cm^2. The wick structure was an annular gap type fabricated from 100 x 100 mesh Nb-1%Zr screen. Rigorous fabrication and cleaning procedures are believed to be critical to good wetting, resulting in significantly reduced active nucleation site size and a higher boiling limit. The procedure used to clean this heat pipe included acid wash, Freon-TF degrease, ethanol wash, high-vacuum firing, and operation as a lithium heat pipe. A heat pipe boiling limit model, based on the active nucleation site radius, is described. An active nucleation site radius of 6×10^{-6} m (2.4×10^{-4} in) correlates the radial flux boiling limit measured in these tests. 4 refs., 2 figs.

7554 (SAND-89-1635C) **Scaling study for SP-100 reactor technology.** Marshall, A.C. (Sandia National Labs., Albuquerque, NM (USA)); McKissock, B. Sandia National Labs., Albuquerque, NM (USA). [1989]. 8p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-900109–4: 7. symposium on space nuclear power systems, Albuquerque, NM (USA), 7-11 Jan 1990). Order Number DE89014967. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

In this study, we explored several ways of extending SP-100 reactor technology to higher power levels. One approach was to use the reference SP-100 pin design and increase the fuel pin length and the number of fuel pins as needed to provide higher capability. The impact on scaling of a modified and advanced SP-100 reactor technology was also explored. Finally, the effect of using alternative power conversion subsystems, with SP-100 reactor technology was investigated. One of the principal concerns for any space-based system is mass; consequently, this study focused on estimating reactor, shield, and total system mass. The RSMASS code (Marshall 1986) was used to estimate reactor and shield mass. Simple algorithms developed at NASA Lewis Research Center were used to estimate the balance of system mass. Power ranges from 100 kWe to 10 MWe were explored assuming both one year and seven years of operation. Thermoelectric, Stirling, Rankine, and Brayton power conversion systems were investigated. The impact on safety, reliability, and other system attributes, caused by extending the technology to higher power levels, was also investigated. 6 refs., 4 figs., 3 tabs.

7555 **Evaluation of load carrying capabilities of refractory alloys for space reactor power applications.** Horak, J.A. (Oak Ridge National Laboratory, TN (USA)). *TMS (The Metallurgical Society) Paper Selection (USA)*, 56: 65 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Refractory metal alloys possess the required combination of long-term high temperature strength properties required for fuel cladding and/or structural applications for Space Nuclear Power Systems. A quantitative evaluation of the mechanical properties of several refractory alloys relevant to a system design lifetime of seven years at temperatures between 800 and 1275 C is being conducted. Currently being evaluated are selected tantalum-, molybdenum-, niobium-, and tungsten-base alloys. Of principal interest at this time are creep and fatigue properties as a function of applied stress, test temperature, test environment, and thermochemical history. Creep properties of the above alloys have been calculated. This evaluation provides an assessment of the existing data and the data requirements necessary to assure success of the Space Nuclear Power Systems Program.

2107 Regulation and Licensing

Refer also to citation(s) 7513, 7524, 7583, 7584, 7588, 7591, 7593, 7594

7556 (NUREG–0020-Vol.13-No.9) **Licensed operating reactors: Status summary report data as of August 31, 1989: Volume 13, Number 9.** Nuclear Regulatory Commission, Washington, DC (USA). Office of Information Resources Management. Nov 1989. 508p. Sponsored by Nuclear Regulatory Commission. Available from NTIS, PC A22/MF A01 - GPO; OSTI; INIS.

The US Nuclear Regulatory Commission's monthly Licensed Operating Reactors Status Summary Report provides data on the operation of nuclear units as timely and accurately as possible. This information is collected by the Office of Information Resources Management, from the Headquarters Staff of NRC's Office of Inspection and Enforcement, from NRC's Regional Offices, and from utilities. Since all of the data concerning operation of the units is provided by the utility operators less than two weeks after the end of the month, necessary corrections to published information are shown on the errata page.

7557 (NUREG/CR–2000-Vol.8-No.10) **Licensee Event Report (LER) compilation for month of October 1989.** Nuclear Regulatory Commission, Washington, DC (USA). Office for Analysis and Evaluation of Operational Data; Oak Ridge National Lab., TN (USA). Nov 1989. 112p. Sponsored by Nuclear Regulatory Commission. DOE Contract AC05-84OR21400. (ORNL/NSIC–200-Vol.8-No.10). Available from NTIS, PC A06/MF A01 - GPO - OSTI.

This monthly report contains Licensee Event Report (LER) operational information that was processed into the LER data file of the Nuclear Safety Information Center (NSIC) during the one month period identified on the cover of the document. The LERs, from which this information is derived, are submitted to the Nuclear Regulatory Commission (NRC) by nuclear power plant licensees in accordance with federal regulations. Procedures for LER reporting for revisions to those events occurring prior to 1984 are described in NRC Regulatory Guide 1.16 and NUREG-0161, Instructions for Preparation of Data Entry Sheets for Licensee Event Reports. For those events occurring on and after January 1, 1984, LERs are being submitted in accordance with the revised rule contained in Title 10 Part 50.73 of the Code of Federal Regulations (10 CFR 50.73 – Licensee Event Report System) which was published in the Federal Register (Vol. 48, No. 144) on July 26, 1983. NUREG-1022, Licensee Event Report System – Description of Systems and Guidelines for Reporting, provides supporting guidance and information on the revised LER rule.

22 NUCLEAR REACTOR TECHNOLOGY

Refer also to citation(s) 7668, 8995

2201 Theory and Calculation

Refer also to citation(s) 7546, 7598, 7599

7558 (IRI–1987) **Annual report 1987.** Interuniversitair Reactor Inst., Delft (Netherlands). 1988. 184p. (In Dutch). Order Number DE90705955. Available from NTIS (US Sales Only), PC A09/MF A01 - OSTI.

In this annual report of the Dutch Interfacultary Reactor Institute, summary and detailed reports are presented of current research during 1987 of the departments radiochemistry, radiation chemistry, radiation physics and reactor physics. 61 refs., 13 figs., 14 tabs.

7559 (IRI–1988) **IRI scope of activities, 1988.** Interuniversitair Reactor Inst., Delft (Netherlands); Technische Univ. Delft (Netherlands). 1989. 68p. Order Number DE90705954. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI.

This report presents a survey of the current research and education programs during 1988 of the departments radiochemistry, radiation chemistry, radiation physics and reactor physics of the Dutch Interfacultary Reactor Institute. 25 figs., 4 tabs.

7560 (IRI–1989) **WOP '89: Activity and development plan.** Interuniversitair Reactor Inst., Delft (Netherlands). 1989. 62p. (In Dutch). Order Number DE90705953. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI.

The Interfaculty Reactor Institute is an interfaculty research institute of the Technical University, Delft. The faculties involved are those of Technical Physics, Chemical Technology and Material Sciences, of which the first one acts as conducting faculty. Research and education take place in four departments: Radiochemistry, Radiation chemistry, Radiation physics and Reactor physics. In this report the working-programmers involved for the year 1989 and the development-programs 1990–1993 are presented. Also the projects of the section Instrumentation Radiation-research of the group Spectroscopy and Radiation-technology of the faculty of Technical Physics have been taken up briefly. The projects of the supporting services and operation groups are indicated. The estimates are presented apart from the working-/development-program. 9 tabs.

2202 Components and Accessories

Refer also to citation(s) 7527, 7597, 7598, 7907, 7908, 8157, 9014

7561 (CONF-8910222–7) **Improved eddy-current inspection for steam generator tubing.** Dodd, C.V. (Oak Ridge National Lab., TN (USA)); Pate, J.R.; Allen, J.D. Jr. Oak Ridge National Lab., TN (USA). [1989]. 15p. Sponsored by Nuclear Regulatory Commission. DOE Contract AC05-84OR21400. DOE-1886-8041-7B. From 17. water reactor safety information meeting; Rockville, MD (USA); 23-25 Oct 1989. Order Number DE90003705. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Computer programs have been written to allow the analysis of different types of eddy-current probes and their performance under different steam generator test conditions. The probe types include the differential bobbin probe, the absolute bobbin probe, the pancake probe and the reflection probe. The generator test conditions include tube supports, copper deposits, magnetite deposits, denting, wastage, pitting, cracking and IGA. These studies are based mostly on computed values, with the limited number of test specimens available used to verify the computed results. The instrument readings were computed for a complete matrix of the different test conditions, and then the test conditions determined as a function of the readings by a least-squares technique. A comparison was made of the errors in fit and instrument drift for the different probe types. The computations of the change in instrument reading due to the defects have led to an "inversion" technique in which the defect properties can be computed from the instrument readings. This has been done both experimentally and analytically for each of these probe types. 3 refs., 13 figs., 1 tab.

7562 (EPRI-NP–6557) **Numerical simulation of bubbly flow: Final report.** Stuhmiller, J.H. (JAYCOR, San Diego, CA (USA)); Ferguson, R.E.; Meister, C.A. Electric Power Research Inst., Palo Alto, CA (USA); JAYCOR, San Diego, CA (USA). c Nov 1989. 522p. Sponsored by Electric Power Research Institute. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

A direct, numerical simulation of gas-dispersed two-phase flow has been developed. Each bubble in the flow is tracked from its inception, either at an orifice or at a nucleation site on the wall, until it flows our of the region of interest or disappears because of condensation. Thousands of bubbles may be tracked simultaneously, each interacting mechanically and thermodynamically with each other, the liquid, and the geometry of the flow channel. The result is a numerical experiment that can be used to interpret every aspect of a physical experiment and than can be used to generate relations for critical two-phase flow processes, such as interfacial heat, mass, and momentum transfer rates and subcooled boiling and flow regime transition. The simulation has been compared with experimental data in pipes, channels, and simple rod bundles; for air/water, steam/water, and Freon liquid/vapor; for saturated and subcooled inlet flow; and for every kind of two-phase flow instrumentation. 15 refs., 292 figs.

7563 (NUREG/CR–5469) **Irradiation-anneal-reirradiation (IAR) studies of prototypic reactor vessel weldments.** Hawthorne, J.R. (Materials Engineering Associates, Inc., Lanham, MD (USA)). Nuclear Regulatory Commission, Washington, DC (USA). Div. of Engineering; Materials Engineering Associates, Inc., Lanham, MD (USA). Nov 1989. 193p. Sponsored by Nuclear Regulatory Commission. (MEA–2364). Available from NTIS, PC A10/MF A01 - GPO; OSTI; INIS.

The usefulness of intermediate annealing to periodically mitigate the deleterious effects of nuclear radiation on reactor pressure vessel steels is explored. Test materials are intermediate and high copper content weld deposits made commercially. Irradiation and reirradiation exposures were at 288°C. Annealing-induced properties recovery and resistance to reembrittlement by irradiation are qualified for 454°C and 399°C heat treatments and a total fluence of 2.7×10^{19}n/cm^2. Tendencies toward a saturation of radiation embrittlement were observed in annealed material. With 454°C annealing, embrittlement levels were lower than those observed after irradiation to 1.5×10^{19}n/cm^2 without intermediate annealing. The method shows high promise for radiation-sensitive pressure vessel steels for increasing their fracture-safe service lifetimes. 22 refs., 27 figs., 5 tabs.

2203 Fuel Elements

Refer also to citation(s) 8554

7564 (JAERI-M–89-095) **Development and verification of the FP behavior evaluation computer code: FPRETAIN: Release and retention of FP from pre-irradiated fuel rods.** Yanagisawa, Kazuaki (Japan Atomic Energy Research Inst., Tokai, Ibaraki (Japan). Tokai Research Establishment). Japan Atomic Energy Research Inst., Tokyo (Japan). Jun 1989. 175p. (In Japanese). Order Number DE90733141. Available from NTIS (US Sales Only), PC A08/MF A01.

This paper describes results of development and verification study by FP behavior evaluation computer code: FPRETAIN, which has been developed to understand the fuel behavior at extended burn-up stages. The birth, the release and the retain process of various kinds of fission products in the fuel pellet and fuel mechanical behavior were modelled in the code. In this work, open-to-public data obtained from several test reactors (Halden Boiling Water Reactor, Studsvik R2 Reactor and Riso DR-3 Reactor) and from the domestic commercial power reactor were utilized for verification. Concluding remarks obtained are: (1) Regarding fuel centerline temperatures as a function of rod linear power and burn-up, calculation coincided well with experiment up to the burn-ups range of 20 MWd/kgU. (2) At burn-ups within 20 MWd/kgU, increased plenum pressures by released Xe and Kr gases were well predicted. (3) On release rate of the stable gaseous FP to burn-up range up to 35 MWd/kgU, it was understood that the code was tended to make under-estimation, especially at increased burn-up stages. The code calculation against fuels from domestic reactors, however, resulted in good agreement with post irradiation data. (4) Within burn-up ranges up to 35 MWd/kgU, hoop strain calculated by the code coincided well with data obtained from experiment. (5) Regarding

retained FP gas distribution in a fuel, the calculation agreed with experimental data qualitatively. (author).

7565 (WSRC-RP–89-344) **Reactor charge and discharge computer control system.** Hart, M.M. Westinghouse Savannah River Co., Aiken, SC (USA). [1989]. 12p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. (CONF-891192–19: Annual Westinghouse computer symposium, Pittsburgh, PA (USA), 6-7 Nov 1989). Order Number DE90003886. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The Reactor Charge and Discharge (C&D) Computer Control System automates the remote loading and unloading of fuel, targets, and other components from production reactors at the Savannah River Site. The systems are currently being prepared by the Equipment Engineering Section and Reactor Engineering Department of the Savannah River Site. The design is a 32 bit VME based system to replace obsolete eight bit computers currently used for control. The C&D Computer Control System will validate each order and control the motion and position of each machine for tandem operation of both machines. This system consists of three independent computers, the C Controller, the D Controller, and the Sequencer. The C and D Controllers are similar in that each interfaces with the relay control logic, limit switches, synchros, and motor drives of their respective machines. These machines (often referred to as cranes) are bridge and trolley machines, each with three masts to handle the pickup and deposit of fuel, target, and control rod assemblies, and other replaceable reactor components. The Sequencer contains the entire complement of orders for a complete charge and discharge operation. The orders are issued, one at a time, to the Controllers to insure the machines operate in tandem to complete specific reactor recharging operations. 6 figs.

2204 Control Systems

Refer also to citation(s) 7592, 7595, 7895

7566 (CONF-900143–3) **A new approach to controlling the water level of U-tube steam generators.** March-Leuba, C.; March-Leuba, J.; Wilson, T.L. Oak Ridge National Lab., TN (USA). [1989]. 7p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. From Nuclear science symposium; San Francisco, CA (USA); 22-26 Jan 1990. Order Number DE90003710. Available from NTIS, PC A02/MF A01; OSTI; INIS.

Automatic water level control in steam generators is currently achieved via a three-element controller. This algorithm is based on the measurements of level, steam flow, and feedwater flow. Unfortunately, at low power the feedwater flow signal is highly unreliable, forcing the transfer to manual control. A large number of reactor trips occur under these conditions, and the nuclear industry has shown a concern for this problem. This paper proposes and validates an alternative automatic control algorithm. This new algorithm does not rely on flow signals; it uses instead the pressure measurement in the steam header. A level set point modulation is introduced that allows the algorithm to compensate for shrink and swell phenomena. The standard Δ-P algorithm to control feedwater pump speed also has been modified to achieve improved performance and integration. 2 refs., 12 figs.

7567 (INIS-mf–11518) **Stability monitoring of a natural-circulation-cooled boiling water reactor.** van der Hagen, T.H.J.J. Technische Univ. Delft (Netherlands). 9 Mar 1989. 153p. Order Number DE90705959. Available from NTIS (US Sales Only), PC A08/MF A01 - OSTI.

Methods for monitoring the stability of a boiling water reactor (BWR) are discussed. Surveillance of BWR stability is of importance as problems were encountered in several large reactors. Moreover, surveying stability allows plant owners to operate at high power with acceptable stability margins. The results of experiments performed on the Dodewaard BWR (the Netherlands) are reported being considered for new reactor designs. The stability of this reactor was studied both with deterministic methods and by noise analysis. Three types of stability are distinguished and were investigated separately: reactor-kinetic stability, thermal-hydraulic stability and total-plant stability. It is shown that the Dodewaard reactor has very large stability margins. A simple yet reliable stability criterion is introduced. It can be derived on-line from the noise signal of ex-vessel neutron detectors during normal operation. The sensitivity of neutron detectors to in-core flux perturbations – reflected in the field-of-view of the detector – was calculated in order to insure proper stability surveillance. A novel technique is presented which enables the determination of variations of the in-core coolant velocity by noise correlation. The velocity measured was interpreted on the basis of experiments performed on the air/water flow in a model of a BWR coolant channel. It appeared from this analysis that the velocities measured was much higher than the volume-averaged water and air technique to monitoring of local channel-flow stability was tested. It was originating from the local flow pattern. Experimental and theoretical studies show a shorter effective fuel time constant in a BWR than was assumed. 118 refs., 73 figs., 21 tabs.

7568 (ORNL/TM–10650) **Development of a general learning algorithm with applications in nuclear reactor systems.** Brittain, C.R.; Otaduy, P.J.; Perez, R.B. Oak Ridge National Lab., TN (USA). Dec 1989. 97p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. Order Number DE90004375. Available from NTIS, PC A05/MF A01; OSTI; INIS; GPO Dep.

The objective of this study was development of a generalized learning algorithm that can learn to predict a particular feature of a process by observation of a set of representative input examples. The algorithm uses pattern matching and statistical analysis techniques to find a functional relationship between descriptive attributes of the input examples and the feature to be predicted. The algorithm was tested by applying it to a set of examples consisting of performance descriptions for 277 fuel cycles of Oak Ridge National Laboratory's High Flux Isotope Reactor (HFIR). The program learned to predict the critical rod position for the HFIR from core configuration data prior to reactor startup. The functional relationship bases its predictions on initial core reactivity, the number of certain targets placed in the center of the reactor, and the total exposure of the control plates. Twelve characteristic fuel cycle clusters were identified. Nine fuel cycles were diagnosed as having noisy data, and one could not be predicted by the functional relationship. 13 refs., 6 figs.

2205 Environmental Aspects

Refer also to citation(s) 7599, 8420, 8421, 8556, 8558

2206 Research, Test, and Experimental Reactors

Refer also to citation(s) 7524, 7562, 7578, 8171

7569 (CONF-8809221–6) **Some recent observations on the radiation behavior of uranium silicide dispersion fuel.** Hofman, G.L. Argonne National Lab., IL (USA). [1988]. 20p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract W-31109-ENG-38. From International meeting on reduced enrichment for research and test reactors (RERTR); San Diego, CA (USA); 18-24 Sep 1988. Order Number DE90003806. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Addition of B_4C burnable poison results in higher plate swelling in both U_3Si_2 and U_3Si-Al dispersion fuel plates and also decreases the blister threshold temperature of these plates. Prolonged annealing of U_3Si_2-Al fuel plates produced no blister after 696 hours at 400°C. Blister formation started between 257 hours and 327 hours at 425°C and between 115 hours and 210 hours at 450°C. Operation with breached cladding resulted in pillowing of an U_3Si-Al fuel plate due to reaction of the fuel core with coolant water. 4 refs., 10 figs., 2 tabs.

7570 (CONF-8809221–7) **Irradiation behavior of the CNEA's experimental uranium silicide dispersion fuel plates.** Hofman, G.L. (Argonne National Lab., IL (USA)); Marajofsky, A.; Kohut, C. Argonne National Lab., IL (USA). 1988. 25p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract W-31109-ENG-38. From International meeting on reduced enrichment for research and test reactors (RERTR); San Diego, CA (USA); 18-24 Sep 1988. Order Number DE90003800. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Since 1978 the CNEA ECBE project has been involved in the development of dispersion fuel plates with four types of fuel materials – UAl_x, U_3O_8, U_3Si, and U_3Si_2 – to be used in low enriched (LEU < 20% ^{235}U) fuel elements for research reactors. Miniplates with these fuel materials were manufactured at CNEA and were irradiated in the ORR in three series of irradiations as part of the RERTR miniplate irradiation program. The first irradiation contained U_3O_8 and UAl_x fuel, the second U_3O_8, UAl_x and U_3Si, while the third irradiation test consisted of six U_3Si_2 miniplates and one U_3Si miniplate. This third test is the subject of this paper. The present results compare favorably with other irradiations performed in the RERTR program[1,2] showing in particular the excellent behavior of the U_3Si_2. The overall data accumulated support the qualification of the CNEA fabrication techniques. 5 refs., 13 figs., 3 tabs.

2207 Plutonium and Isotope Production Reactors

Refer also to citation(s) 7562, 7580

7571 (EUR–12271) **Annual progress report 1988, operation of the high flux reactor.** Ahlf, J.; Roettger, H. (eds.). Commission of the European Communities, Luxembourg (Luxembourg). 1989. 104p. Available from NTIS (US Sales Only), PC A06/MF A01.

In 1988 the High Flux Reactor Petten was routinely operated without any unforeseen event. The availability was 99% of scheduled operation. Utilization of the irradiation positions amounted to 80% of the practical occupation limit. The exploitation pattern comprised nuclear energy deployment, fundamental research with neutrons, and radioisotope production. General activities in support of running irradiation programmes progressed in the normal way. Development activities addressed upgrading of irradiation devices, neutron radiography and neutron capture therapy.

7572 (GAO/RCED–89-134BR) **Nuclear science: DOE Richland role in the proposal to convert Washington nuclear plant No. 1.** General Accounting Office, Washington, DC (USA). Resources, Community and Economic Development Div. 1989. 30p. Available from US General Accounting Office, PO Box 6015, Gaithersburg, MD 20877.

Information has been requested on a number of issues involving the Department of Energy's possible conversion of a partially completed commercial nuclear power plant to a defense production reactor that would produce material for use in the nuclear weapons program of the United States. Washington Nuclear Plant No. 1–owned by the Washington Public Power Sypply System–is located on DOE's Hanford Reservation near Richland, Washington. This report answers questions that were not addressed in a previous GAO report on the same topic.

7573 (JAERI-M–89-099) **Thermal characteristic test for saturated temperature type capsule.** Niimi, Motoji (Japan Atomic Energy Research Inst., Oarai, Ibaraki (Japan). Oarai Research Establishment); Someya, Hiroyuki; Kobayashi, Toshiki; Ohuchi, Mitsuo; Harayama, Yasuo. Japan Atomic Energy Research Inst., Tokyo (Japan). Aug 1989. 36p. (In Japanese). Order Number DE90733143. Available from NTIS (US Sales Only), PC A03/MF A01.

The Japan Material Testing Reactor Project is developing a new type capsule so-called 'Saturated Temperature Capsule', as a part of irradiation technique improvement program. This type capsule, in which the water is supplied and boiled, bases on the conception of keeping the coolant at the saturated temperature and facilitating the temperature setting of specimens heated by gamma-ray in reactor. However, out-pile test was planned, because there were few usable data for design and operation of the capsule into which the coolant was injected. A out-pile apparatus, simulated the capsule with electric heaters, was fabricated and experiments were carried out, to obtain data concerning design and operation for the capsule into which the water was injected. As a structure of simulated capsule, a type of downward coolant supply was adopted. The downward coolant tube type injectes the water in the bottom of capsule by tube through the upper flange. Major objects of experiences were to grasp thermal features under operation and to provide performances of capsule control equipment. Experimental results proved that the temperature of water within the capsule was easily varied by controlling supply water flow rate, and that the control equipment was operated stably and safety. (author).

7574 (PNL-SA–17248) **Use of pulse neutron source technique for in-plant reactivity measurements.** Bierman, S.R. Pacific Northwest Lab., Richland, WA (USA). [1989]. 9p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC06-76RL01830. (CONF-891118–10: International meeting on nuclear criticality safety margins, San Francisco, CA (USA), 26 Nov - 1 dec 1989). Order Number DE90003639. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Over 25 years of experience at Hanford in adapting and using the pulse neutron source technique to measure the reactivity of out-of-reactor systems are covered. The emphasis at PNL has been to develop a measurement system that was transportable and adaptable to plant conditions. The system that has evolved over the years in centered about a non-cooled 10^9 n/sec, 50 pulses per second neutron source and a data acquisition/analyses system involving four simultaneous data gathering channels and an online PC computer. Measurements can currently be performed and analyzed for k_{eff} in about 30 minutes. However, direct reactivity determinations are effectively limited to systems having k_{eff} of about 0.8 or greater by the relatively small portable source. Actual plant systems and systems simulating plant conditions, on which measurements have been performed, are presented and the results briefly discussed with references. 11 refs., 7 figs.

2208 Propulsion Reactors

Refer also to citation(s) 8987

2209 Reactor Safety

Refer also to citation(s) 7509, 7511, 7513, 7524, 7526, 7551, 7555, 7556, 7561, 7562, 7564, 7565, 7566, 7884, 8157, 8419, 8439, 8794, 9002, 9014

7575 (BMU–1988-200) **Status report on the deflagration/detonation transition in the three-phase diagram hydrogen/air/steam according to Shapiro/Moffette. Final report.** Schriftenreihe Reaktorsicherheit und Strahlenschutz. Ergebnisberichte, Untersuchungen, Studien, Gutachten. Mayinger, F.; Strube, G.; Beauvais, R. Bundesministerium fuer Umwelt, Naturschutz und Reaktorsicherheit, Bonn (Germany, F.R.); Technische Univ. Muenchen (Germany, F.R.). Lehrstuhl A fuer Thermodynamik. Jun 1988. 144p. (In German). Contract BMU SR 403. Available from Available from GRM Werbeberatung - Werbemittlung - PR, Eggenstein-Leopoldshafen, (Germany, F.R.).

On the basis of a bibliographic study, the present level of knowledge about the combustion of hydrogen/air/steam mixtures, in particular, knowledge about transition from deflagration to detonation (DDT) is recorded. The numerical calculation of combustion processes produces good results; at present, however, a comprehensive simulation of highly turbulent flames is not yet possible. A consistent model for DDT based on the instability of highly turbulent flame fronts with high spreading rates is capable of explaining the transitions to detonation found in a diversity of test arrangements. At the same time, the same model provides a criterion with which conservative limits for DDT can be determined in the three-component diagram. It is extremely difficult to give a reliable estimate of the situation of H_2 in hypothetical developments of heavy core meltdown accidents with the help of the limits found. All that can be said at present is that danger originating from hydrogen can only arise after concrete melt interaction has taken place. In this case, DDT cannot be precluded, at least in some compartments of the safety vessel. (orig.).

7576 (BNL-NUREG–43404) **The uses and benefits of probabilistic risk assessment in nuclear reactor safety.** Bari, R.A. (Brookhaven National Lab., Upton, NY (USA)); Speis, T.P. Brookhaven National Lab., Upton, NY (USA). [1989]. 8p. Sponsored by Nuclear Regulatory Commission. DOE Contract AC02-76CH00016. (CONF-8910227–2: 50. anniversary of nuclear fission, Leningrad (USSR), 16-20 Oct 1989). Order Number DE90003263. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Probabilistic risk assessment (PRA) has proven to be an important tool in the safety assessment of nuclear reactors throughout the world. Decision making with regard to many safety issues has been facilitated by both general insights from and direct application of this technology. Key uses of PRA are discussed and some examples of successful applications are cited. The benefits and limitations of PRA are also discussed as well as the broader outlook for applications of PRA. 9 refs.

7577 (CONF-891103–61) **Heatup of the TMI-2 lower head during core relocation.** Wang, S.K.; Sienicki, J.J.; Spencer, B.W. Argonne National Lab., IL (USA). [1989]. 17p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract W-31109-ENG-38. From Winter meeting of the American Nuclear Society; San Francisco, CA (USA); 26-30 Nov 1989. Order Number DE90003778. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

An analysis has been carried out to assess the potential of a melting attack upon the reactor vessel lower head and incore instrument nozzle penetration weldments during the TMI core relocation event at 224 minutes. Calculations were performed to determine the potential for molten corium to undergó breakup into droplets which freeze and form a debris bed versus impinging upon the lower head as one or more coherent streams. The effects of thermal-hydraulic interactions between corium streams and water inside the lower plenum, the effects of the core support assembly structure upon the corium, and the consequences of corium relocation by way of the core former region were examined. 19 refs., 24 figs.

7578 (CONF-8711245–7) **Personalization of ENEA engineering simulator to Italian nuclear power plant PWR-PUN.** Mattucci, A. ENEA, Casaccia (Italy). Centro Ricerche Energia. Nov 1987. 25p. From Workshop on computers applications for nuclear powers and industrial process plant operation and control; Rome (Italy); 19-20 Nov 1987. Order Number DE89761979. Available from NTIS (US Sales Only), PC A03/MF A01.

Paper presented at ENEA-Halden reactor project workshop on computer applications for nuclear power and industrial process plant operation and control (Rome, 19-20 Nov 1987).

The development of simulators, capable of handling in real time a wide variety of accident conditions in nuclear power plants, is described. For illustrative purposes, a description of the ENEA (Italian Commission for Nuclear and Alternative Energies) engineering simulator, being designed for an Italian nuclear power plant, PWR-PUN, is provided. The work that ENEA is performing to adapt the simulator to the power plant is also indicated, together with the actual status of the project. The simulator is being designed to perform the following tasks: analysis of plant transients, even with operator's impact on plant management taken into account; studies to improve overall design and system performance; design and verification of control and protection systems (including system interaction analysis); studies of man-machine interface and verification of control room lay-out;validation of the integrated protection and control system prototype; pre-training of plant personnel.

7579 (CONF-8909141–9) **Additional capabilities and benchmarking with the SPERT transients for heavy water application of the PARET code.** Woodruff, W.L. Argonne National Lab., IL (USA). [1989]. 15p. Sponsored by U.S. Arms Control and Disarmament Agency; U.S. DOE Assistant Secretary for International Affairs and Energy Emergencies. DOE Contract W-31109-ENG-38. From 12. international meeting on reduced enrichment for research and test reactors; Berlin (Germany, F.R.); 10-13 Sep 1989. Order Number DE90003801. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The capabilities of the PARET code have been expanded to include the ability to compute steady-state and transient results for heavy water reactors. A comparison is provided between PARET and the SPERT II series of transients. Another significant improvement in the code is the addition of a restart capability. The current capabilities of the code are summarized. 7 refs., 12 figs., 3 tabs.

7580 (CONF-8910222–10) **Environmentally assisted cracking in light water reactors.** Kassner, T.F.; Park, J.Y.; Ruther, W.E.; Schack, W.J. Argonne National Lab., IL (USA). Nov 1989. 32p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract W-31109-ENG-38. From 17. water reactor safety information meeting; Rockville, MD (USA); 23-25 Oct 1989. Order Number DE90003799. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Topics that have been considered during this year include (1) stress corrosion cracking (SCC) of austenitic stainless steels (SS), (2) fatigue of Type 316NG SS, and (3) SCC of ferritic steels used in reactor piping, pressure vessels, and steam generators. Constant-extension-rate-tests (CERTs) and crack-growth-rate (CGR) tests on 1TCT specimens were performed to quantify the effects of chromate, sulfate, chloride, and low levels of organic impurities on SCC of sensitized Type 304 and Type 316NG SS. Some organic substances were found to actually inhibit SCC of sensitized Type 304 SS. Fatigue tests on Type 316NG SS showed that even at 0.5 Hz the fatigue life in the environment is about half of that in air, and the reduction in life increases at lower frequencies. CGR tests on A533-Gr B pressure vessel steel are in progress on conventional specimens and composite specimens of A533-Gr B/Inconel-182/Inconel-600. Some of the specimens have been plated with either nickel or gold to reduce contact between the surface of low-alloy steel and the environment. Comparison of the results from the bare and plated specimens will provide insight into whether electron transfer through the oxide film on the bulk surface of the ferritic steel is important in the overall SCC process. 49 refs., 16 figs., 9 tabs.

7581 (DPST–86-406) **Summary report on the release of fission products from irradiated SRP fuel at elevated temperatures.** Whitkop, P.G. Savannah River Lab., Aiken, SC (USA). 21 Apr 1986. 8p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. Order Number DE90003914. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Current SRP reactor source term assumptions are based on a document which details procedures that can be used to judge site/facility suitability as outlined in 10 CFR Part 100. These procedures and assumptions are similar to those used for commercial nuclear reactors, but have been modified to reflect the fact that confinement rather than containment is used to mitigate accidents and that design differences between commercial and SRP reactors lead to different postulated accident sequences. The source term assumptions outlined are based on data obtained prior to 1962. Since then, and particularly after the incident at Three Mile Island, a vast source term literature has evolved. In order for SRP source term assumptions to remain consistent with modern approaches, a fuel melting experiment conducted under contract with Hanford Engineering Development Laboratory (HEDL) was initiated. These experiments specifically focused on fission product release from U/Al alloy and U_3O_8/Al powder metallurgy fuels irradiated in SRP reactors. The effects of temperature and atmosphere on fission product release were investigated. In addition to these measurements, some of the important chemical interactions among the fission products and between fission products and various atmospheric constituents were investigated. A report (HEDL-7598) has been issued to describe these experiments and their results. This DPST report summarizes the results of the fuel melt experiments detailed in HEDL-7598 and compares them to current SRP source term assumptions.

7582 (ENEA-RT-PAS–85-1) **Characterization of aerosols produced during cutting of steel and concrete components by means of a laser beam.** Tarroni, G.; Melandri, C.; De Zaiacomo, T.; Lombardi, C.C.; Formignani, M. Comitato Nazionale per l'Energia Nucleare, Bologna (Italy). Apr 1985. 33p. (In Italian). Order Number DE89761978. Available from NTIS (US Sales Only), PC A03/MF A01.

The cutting of reinforced concrete structures during the dismantling of nuclear power stations poses a radiation hazard to workers and environment since, by this procedure, large quantities of aerosols are produced. This report describes the techniques used to study the aerosols produced during the cutting of steel and concrete components by means of a laser beam. Experimental data is presented together with a discussion about problems not yet solved. For example, the determination of the precise chemical composition of the aerosols is made difficult due to the fact that their composition is greatly influenced by the violent and complex reactions occuring at the cutting planes.

7583 (EPRI-NP–6558) **The 1986 Leroy, Ohio, earthquake: Performance of power and industrial facilities: Final report.** Wilson, P. (Stevenson and Associates, Cleveland, OH (USA));

Stevenson, J.D. Electric Power Research Inst., Palo Alto, CA (USA); Stevenson and Associates, Cleveland, OH (USA). c Nov 1989. 79p. Sponsored by Electric Power Research Institute. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

A magnitude 5.0 earthquake which struck north-east Ohio on January 31, 1986 was investigated primarily for its effects on power, industrial and commercial facilities. A reconnaissance was performed by Stevenson and Associates for the Electric Power Research Institute (EPRI). The reconnaissance was performed for the most part within 10 miles of the epicenter which has been located 41.650° N and 81.162° W in Leroy township approximately 9 miles southwest of Painesville, Ohio. In addition to the reconnaissance performed by Stevenson and Associates immediately following the event, reports from other sources, particularly with respect to the Cleveland Electric Illuminating Company power distribution and generating facilities and public schools in Madison and Mentor, have been used to prepare this report. 14 refs., 40 figs., 5 tabs.

7584 (EPRI-NP–6601) **BWR (Boiling Water Reactor) reactor vessel in-service inspection database: Final report.** Mattu, R.K. (Science Applications International Corp., McLean, VA (USA)); Anderson, W.F.; Connor, L.; Kapila, V.M. Electric Power Research Inst., Palo Alto, CA (USA); Science Applications International Corp., McLean, VA (USA). c Nov 1989. 129p. Sponsored by Electric Power Research Institute. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

Section 11 of the ASME Boiler and Pressure Vessel Code, "Rules for In-service Inspection of Nuclear Power Plant Components," provides rules for inspection of nuclear reactor vessels. The first edition of that section of the Code in 1971, provided rules to be applied to existing designs, even though some of those designs made no provision for inspection or access by personnel for inspection in radioactive areas. The 1971 edition recognized the problem and provided for examining such areas with remotely-controlled equipment, which would have to be developed, and provided for deferral of the remotely-controlled examinations until late in the 10-year inspection interval to allow time for development of equipment and procedures. The design and construction of most of the existing BWRs was well underway before the inspection requirements were in place, and did not allow for introduction of remotely-controlled equipment. Available records of in-service inspection plans and examination results for all operating US BWRs (including types from Type 1 to Type 6) have been entered into a database that also includes results of examinations, access descriptions, and relief requests. The data show that accessibility of shell welds below the top of the shield wall is largely a function of BWR type; accessibility for inspection of nozzles and lower head welds is more a function of specific plant design and manufacture. 14 figs., 25 tabs.

7585 (EWE–2572-01) **Probabilistic safety analysis procedures guide.** Ministry of social affairs and employment-Electrowatt Engineering Services Collaboration. Ministerie van Sociale Zaken en Werkgelegenheid, The Hague (Netherlands). Kernfysische Dienst. May 1987. 85p. Order Number DE90705962. Available from NTIS (US Sales Only), PC A05/MF A01 - OSTI.

The objective of this document is to specify, and to provide guidance as to the requirements of a Probabilistic Safety Analysis (PSA) to be submitted to the relevant authority in support of the license application for new nuclear power generating plant. The study goals, to be subdivided into probabilistic and deterministic, are defined and the requirements for each phase of the study, namely: plant analysis, containment analysis and environmental consequence analysis are presented.

7586 (INIS-mf–12031) **Analysis of imaginable sequences of the incident at Biblis A nuclear power plant on December 17, 1987. Summary.** Elektrowatt Ingenieurunternehmung G.m.b.H. (EWI), Mannheim (Germany, F.R.); Bundesministerium fuer Umwelt, Naturschutz und Reaktorsicherheit, Bonn (Germany, F.R.). 10 Jan 1989. 18p. (In German). Order Number DE90732343. Available from NTIS (US Sales Only), PC A03/MF A01.

On December 17, 1987, an attempt was made to close the open 2TH22 S006 primary shut-off valve in the Biblis nuclear power plant A by opening the 2TH52 S002 test valve. In addition to the load observed during the event, the relevant load for four more scenarios assumed was studied and its impact on reactor safety assessed. At least one additional fault, e.g., the failure of a component, must occur for each of the four scenarios. The calculation done on the basis of the TRD and AD standard rules or of DIN 17440, together with the load from internal pressure, appeared to be permissible for the assessment, in accordance with KTA 3201.2. This analysis suggested (from a technical point of view) that no failure with catastrophic dimensions would have been possible. (DG).

7587 (INIS-mf–12032) **Development of a plasma-arc-cutting technology like a mechanical saw for dismantling nuclear components of greater thickness under water. Final report.** Bach, F.W.; Jaeger, M. Hannover Univ. (Germany, F.R.). Inst. fuer Werkstoffkunde; Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). May 1989. 119p. (In German). Contract BMFT 02 S 7287. Order Number DE90732505. Available from NTIS (US Sales Only), PC A06/MF A01.

1. Status of research: Cutting steel with the plasma-arc-saw (saw disk diameter 600 mm) with a thickness up to 100 mm is possible. The cutting process works discontinuously. For the ignition of the special constructed plasma torches it is necessary to stop the rotation of the saw disk so the cutting process works discontinuously. 2. Aim of research work: Plasma arc cutting technology should be developed to enable cutting component parts continuous and computer aided. 3. Method of research: Cutting results of the plasma-arc-saw (saw disk diameter 600 mm) gives design data for the construction of a plasma arc saw with a diameter of 850 mm and a diameter of 1000 mm. To develop and optimize the special nozzles of the plasma-arc-saw experiments with the submerged combustion burner have been performed. 4. Results: There are no problems of thermal cutting a plate of steel and a heat exchanger up to a thickness of 300 mm. The cuttable sheet thickness only depends on the diameter of the saw blade. The emission of dust and aerosol only depends on the melted material. Computer aided cutting is possible. 5. The plasma-arc-saw enables thermal cutting of component parts independent of their thickness in a water depth of 20 m without requiring a force. The remote control dismantling of a reactor vessel and other components with greater wall thickness is possible. (orig.) With 34 refs., 2 tabs., 101 figs.

7588 (NUREG–0090-Vol.12-No.2) **Report to Congress on abnormal occurrences, April–June 1989: Volume 12, Number 2.** Nuclear Regulatory Commission, Washington, DC (USA). Office for Analysis and Evaluation of Operational Data. Oct 1989. 29p. Sponsored by Nuclear Regulatory Commission. Available from NTIS, PC A03/MF A01 - GPO - OSTI.

The Energy Reorganization Act of 1974 identifies an abnormal occurrence as an unscheduled incident or event which the Nuclear Regulatory Commission determines to be significant from the standpoint of public health or safety and requires a quarterly report of such events to be made to Congress. For this reporting period, there was one abnormal occurrence at nuclear power plants licensed to operate involving significant deficiencies in management controls at Slurry Nuclear Power Station. There was one abnormal occurrence under other NRC-issued licenses; the event involved a medical therapy misadministration. One other abnormal occurrence, involving industrial radiography overexposures, was reported by an Agreement State (Texas). 40 refs.

7589 (NVR–2-3) **Quality assurance with regard to the safety to nuclear power plants: Dutch version of the code of practice 'Quality assurance for safety in nuclear power plants'.** IAEA safety series No. 50-C-QA. Ministerie van Sociale Zaken en Werkgelegenheid, The Hague (Netherlands). Oct 1988. 24p. (In Dutch). Order Number DE90705943. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI.

This document forms part of a set of safety-foundations and safety rules for nuclear power plants which are employed by governments services charged with the execution of laws for these installations. These services use the foundations and rules in the judgment of the safety aspects of a demand for a license for the establishment or operation of a nuclear power plant and in the supervision during construction and operation of the plant. This document provides the foundations and objects which have to be satisfied in the drawing up and introduction of a quality system, which covers procedures and rules for, among other things, the totality of selection and

preparing of the construction place, the design, fabrication, construction, putting in operation, management and dismantling of components, systems and other matters which are important for the safety. These procedures and rules have to be applied to activities which influence the quality such as designing, purchasing, manufacturing, transporting, storing, cleaning, drawing up, installation, testing, putting in operation, keeping everyone which is responsible for the safety of the nuclear power plant such as designers, suppliers, engineer offices, contractors, operators and other organizations which participate in activities which influence the quality.

7590 (ORNL/FTR–3427) **[Severe accident technology of BWR (Boiling Water Reactor) reactors]: Foreign trip report, September 25–October 2, 1989.** Ott, L.J. Oak Ridge National Lab., TN (USA). 23 Oct 1989. 17p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. 1886-8045-2B. Order Number DE90003946. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The traveler attended the 1989 CORA Workshop at KfK, FRG. Participation included the presentation included the presentation of three papers on work performed by the Boiling Water Reactor Severe Accident Technology (BWRSAT) program at Oak Ridge National Laboratory (ORNL) in Boiling Water Reactor (BWR) severe accident analyses. The Statement of Work (June 1989) for the BWRSAT Program provides for code analyses of the BWR CORA experiments performed at KfK. Additionally, it is intended that BWRSAT personnel participate in the planning process for future CORA BWR experiments. For these purposes, meetings were held with KfK staff to arrange for acquisition of detailed CORA facility drawings, experimental data, and related engineering. 17 refs.

7591 (ORNL/TM–10416) **Conceptual design for a land decontamination robot.** Zimmerman, G.P. Oak Ridge National Lab., TN (USA). Nov 1989. 35p. Sponsored by U.S. DOE Environment Health & Safety. DOE Contract AC05-84OR21400. Order Number DE90004378. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This study investigates the development of a machine for the cleanup and/or treatment of land areas contaminated by a nuclear accident. This system of hardware components could remove radioactive, fallout-type contamination from rolling terrain, such as agricultural farm. This mobile system is remotely operable. This system could be referred to as "a land decontamination robot." A survey of vendors has identified a set of hardware components which are commercially available and not special development items. These components include a large vacuum loader unit, a vehicle for moving the unit around the contaminated area, an industrial robot arm for moving the vacuum nozzle over the contaminated surface, an electronic remote control system, and a position determination system to assist with steering the vehicle on subsequent passes around the contaminated area. Cost estimates were developed for each component. Two versions of the "decontamination robot" were considered: (1) a truck-mounted vacuum loader unit, and (2) a trailer-mounted unit pulled by a bulldozer-type crawler. The costs of the hardware components for the truck-mounted unit are about $450,000; the trailer-mounted unit is about 10% more expensive. These costs are only the hardware costs; the costs associated with integrating this hardware into an operating decontamination system have not been included. Also not included are the costs of programming the sweeping motion of the robot arm and of any computer equipment or software necessary to process and display information relating to the vehicle's position within the contaminated area. It is assumed that these costs will at least equal the cost of the hardware and will thus move the total cost for the complete land decontamination robot system to a minimum of $1,000,000. 25 refs., 2 figs., 4 tabs.

7592 (SAND–88-7058) **Diesel starting system monitor: Prototype development.** DeBey, T.M. (DeBey (T.M.), Lakewood, CO (USA)). Sandia National Labs., Albuquerque, NM (USA). Jul 1989. 24p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC04-76DP00789. Order Number DE90004425. Available from NTIS, PC A04/MF A01; OSTI; INIS.

The US Department of Energy (DOE) effort to extend the operational lives of commercial nuclear power plants is examining methods for predicting the performance of specific equipment. This paper focuses on predictive monitoring as a means for reducing equipment surveillance, maintenance, and outages. Realizing these goals will result in nuclear plants that are more reliable, have lower maintenance costs, and have longer lives. This report describes a prognostic monitoring system that has been developed to predict starting performance in emergency diesels. A prototype system has been built and tested on an engine at Sandia National Laboratories. 6 refs., 8 figs.

7593 (SAND–89-1631C) **Performance of containment penetrations under severe accident loadings.** Parks, M.B.; Clauss, D.B. Sandia National Labs., Albuquerque, NM (USA). [1989]. 31p. Sponsored by Nuclear Regulatory Commission. DOE Contract AC04-76DP00789. (CONF-8910222–11: 17. water reactor safety information meeting, Rockville, MD (USA), 23-25 Oct 1989). Order Number DE90003950. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The paper provides a summary of efforts to date to better understand the leakage behavior of containment penetrations when subjected to severe accident conditions. The research activities discussed herein are a part of the Containment Integrity Programs, which are managed by Sandia National Laboratories for the US Nuclear Regulatory Commission. Past containment penetration research topics, which are briefly described, include testing of typical compression seals and gaskets, electrical penetration assemblies, and a personnel airlock, as well as an investigation of leakage due to ovalization of penetration sleeves. The primary focus of the paper is on recent or ongoing research programs on the behavior of inflatable seals, bellows, and of pressure unseating equipment hatches. 24 refs., 15 figs., 7 tabs.

7594 (VROM–90044/2-89) **Dutch National Plan combat nuclear accidents.** Ministerie VROM-Tweede Kamer der Staten Generaal Collaboration. Tweede Kamer der Staten-Generaal, The Hague (Netherlands). 1988. 227p. (In Dutch). (TK–21015-3). Order Number DE90705964. Available from NTIS (US Sales Only), PC A11/MF A01 - OSTI.

This document presents the Dutch National Plan combat nuclear accidents (NPK). Chapter 2 discusses some important starting points which are determining for the framework and the performance of the NPK, in particular the accident typology which underlies the plan. Also the new accident-classification system for the Dutch nuclear power plants, the standardization for the measures to be taken and the staging around nuclear power plants are pursued. In chapter 3 the legal framework of the combat nuclear accidents is described. In particular, the Nuclear-power law, the Accident law and the Municipality law are pursued. Also the role of province and municipality are described. Chapter 4 deals with the role of the owner/licensee of the object where the accident occurs, in the combat of accident. In chapter 5 the structure of the nuclear-accident combat at national level is outlined, subdivided in alarm phase, combat phase and the winding-up phase. In chapters 6–12 these phases are elaborated more in detail. In chapters 10–13 the measures to be taken in nuclear accidents, are described. These measures are distinguished with regard to: protection of the population and medical aspects, water economy, drinking-water supply, agriculture and food supply. Chapter 14 describes the responsibility of the burgomaster. Chapters 15 and 16 present an overview of the personnel, material, procedural and juridical modifications and supplements of existing structures which are necessary with regard to the new and modified parts of the structure. Chapter 17 indicates how by means of the appropriate education and exercise it can be achieved that all personnel, services and institutes concerned possess the knowledge and experience necessary for the activities from the NKP to be executed as has been described. Chapter 18 contains a survey of activities to be performed and a proposal how these can be realized.

7595 (VROM–90045/2-89) **Note nuclear accidents combat.** Ministerie VROM-Tweede Kamer der Staten Generaal Collaboration. Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, The Hague (Netherlands); Tweede Kamer der Staten-Generaal, The Hague (Netherlands). 13 Feb 1989. 52p. (In Dutch). (TK–21015-1/2). Order Number DE90705963. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI.

In this document the starting points are described which underline the new framework for the nuclear-accident combat in the Netherlands. All the calibration of this is indicated in main lines. The juridical consequences of the proposed structure are enlightened and the sequel activities are indicated. 6 figs., 8 tabs.

7596 (WSRC-RP–89-345) **SIMON (Superintelligent Mobile Observing Navigator): A high-reliability robot for a radiation environment.** Gartner, A.W. Westinghouse Savannah River Co., Aiken, SC (USA). [1989]. 15p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. (CONF-891192–23: Annual Westinghouse computer symposium, Pittsburgh, PA (USA), 6-7 Nov 1989). Order Number DE90003888. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The Robotics Group at the Savannah River Site is developing an autonomous robot to perform monitoring in a reactor radiation zone while the reactor is in operation. The robot will be sealed into a room where it cannot be serviced for the six month reactor cycle. The robot is radio controlled, uses dead reckoning to determine vehicle position, and will dock with a charging stand to replenish its batteries. The system will provide video, temperature, and radiation information. In addition to hardening the robot for the harsh reactor environment, the robot will include many features to ensure that a component failure has minimal impact on the robot with a minimum of redundant systems. Emphasis is being placed on ease of use with a minimal of training and controls to prevent damage by an inexperienced operator. Paths for the robot are preprogrammed and are selected on a graphic map of the room. Additional paths can be entered by authorized personnel. Under manual control, the robot and equipment is protected by a highly effective ultra-sonic collision avoidance system. Under development is a system that will anticipate an unsatisfactory video image and attempt to adjust the receiving antenna's angle for best reception. 5 figs.

7597 (WSRC-RP–89-524) **An expert system for quality assurance.** McGrath, M.B. Westinghouse Savannah River Co., Aiken, SC (USA). [1989]. 15p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. (CONF-891192–22: Annual Westinghouse computer symposium, Pittsburgh, PA (USA), 6-7 Nov 1989). Order Number DE90003887. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

An Expert System to assist and advise engineers and programmers with quality assurance computational software applications has been developed using Level 5 software. The expert system was created using production rule language (logic programming) which launches external Hypercard applications and prompts the user for simple answers in order to print out the appropriate QA forms for a specific quality assurance application. The Level 5 and Hypercard interfaces make for a friendly and reliable system which allows for simply maintenance and accessible modifications. 6 figs.

7598 **Modular nuclear steam supply.** Cho, S.R. (Foster Wheeler Energy Applications, Inc., Livingston, NJ (USA)). *Mechanical Engineering (USA)*, 111(10): 84-87 (Oct 1989).

In 1985, the U.S. Department of Energy began a $90 million program to study some basic concepts of nuclear-fueled power generation. The problem was to create an inherently safe, modular nuclear steam supply system that could be installed more quickly and less expensively than current nuclear systems. The DOE chose the Power Reactor Inherently Safe Module as the official nuclear reactor design. The PRISM concept, now called the Advanced Liquid Metal Reactor (ALMR), was developed by a team of 10 companies. Among the interesting features of the ALMR design is the placement of the components and operating systems. The reactor module is placed below grade in a silo that is physically separated from the steam-generating system, much of which is also underground. Safety devices include the reactor auxiliary cooling systems and seismic isolators. The reactor and steam-generating system are connected by piping running through a below-grade tunnel. A key advantage of the ALMR concept is its use of uranium-238 as the primary fuel. U-238 is more plentiful and less expensive than the U-235 used in the reactors of current nuclear plants.

7599 **Reducing uncertainty allowance in core limits calculations.** Carew, J.F. (Brookhaven National Lab., Upton, NY (USA)). *Nuclear Technology (USA)*, 86(1): 17-21 (Jul 1989).

To provide adequate margin between the operating state and the core safety limits, allowance for calculational uncertainties is incorporated in the reactor core operating limits. In practice, these uncertainties are estimated by comparing calculations of the limits with benchmark calculations and/or measurements. The resulting uncertainty estimates include the uncertainties of the benchmark and are overly conservative when the benchmark uncertainties are large. An exact statistical method for subtracting the benchmark uncertainty and determining reduced best-estimate calculational uncertainties is derived. The method is applied to the determination of the upper tolerance (confidence) limit on the calculational uncertainty required in core limits analyses.

7600 **The importance of fission production/aerosol interactions in reactor accident calculations.** Spence, R.D. (Oak Ridge National Lab., TN (USA). Chemical Technology Div.); Wright, A.L. *Nuclear Technology (USA)*, 77(2): 150-160 (May 1987). DOE Contract AC05-84OR21400.

Including fission product vapor interactions with aerosols in reactor accident calculations can significantly alter the predicted consequences of a given accident. For example, a high-velocity, short residence time accident can transport significant amounts of tellurium outside the reactor vessel on the aerosols rather than having the tellurium reacted on the vessel's metal surfaces. In another scenario, a relatively stagnant situation allows equilibration of the vapor/aerosol interactions and deposition of the aerosols inside the core region. Consequently, most of the fission product vapors remain in the core region with the deposited aerosols. The sorption isotherms of CsOH-Ag, CsOH-Cr_2O_3, and CsI-Cr_2O_3 can be represented by modified Freundlich isotherm expressions.

24 POWER TRANSMISSION AND DISTRIBUTION

2401 Power Systems

Refer also to citation(s) 7181

7601 (ETDE-mf–9761936) **Dynamic dispatch of active thermoelectric power: use of second order algorithm.** Granelli, G.P.; Marannino, P.; Montagna, M.; Silvestri, A. Pavia Univ. (Italy); Ente Nazionale per l'Energia Elettrica, Milan (Italy). 1986. 11p. (In Italian). Order Number DE89761936. Available from NTIS (US Sales Only), PC A03/MF A01.

A second order algorithm, based on the Han-Powell algorithm, is used in the dynamic optimization, according to a compact model, of real power. The dynamic approach, particularly useful for the hours characterized by strong load variations (morning peak) and short term dispatch, is dealt with by adding, to the normal static dispatch constraints (modified to take variable loading into account), dynamic constraints relevant to the speed of variation of generated powers. The objective fuel consumption function is corrected by taking into account the reduction in efficiency of the thermal sets in the scheduling of reactive power. Results of tests conducted on networks representative of Italian HVAC systems, have evidenced the optimum characteristics of the algorithm for that which regards convergence and calculation times.

7602 (IEEJ–8903) **1989 national convention record IEE Japan (Part 11).** Institute of Electrical Engineers of Japan, Tokyo (Japan). Apr 1989. 270p. (In Japanese). Order Number DE89910083. Available from NTIS (US Sales Only), PC A12/MF A01.

From presented articles of the national convention, IEE Japan opened in April, 1989, the articles are recorded of the power cable and energy generation/conversion section, and the symposium Current status of fuel cells for practical use. The power cable section includes 72 articles: Construction of the first 8,000A class 275kV compressed gas insulated (CGI) transmission line in the world','Antiseismic characteristics of CGI transmission terminating sets installed on transmission powers, Temperature rise characteristics of vertically laid CGI transmission lines and others. The energy generation/conversion section includes 77 articles: Estimation of solar radiation by meteorological satellite pictures, Errors of sunshine

duration used for the application planning of solar thermal energy, Solar irradiance obtained through glass and vinyl and others. The symposium includes 5 articles: Developmental conditions of phosphoric acid type fuel cells' and others. 210 refs., 549 figs., 137 tabs.

2402 Power System Networks, Transmission and Distribution

Refer also to citation(s) 6777, 7484, 7601, 7624, 7803, 8059, 8060

7603 (CESI–86-19) **Studies to improve the efficiency and reliability of a medium voltage network in Milan (Italy).** Elli, E.; Lionetto, P.; La Magna, S. Centro Elecctrotecnico Sperimentale Italiano, Milan (Italy). Sep 1986. 5p. (In Italian). (CONF-8609450–: 87. meeting of the Italian Electrotechnical Association, Florence (Italy), 29 Sep - 3 oct 1986). Order Number DE89761912. Available from NTIS (US Sales Only), PC A02/MF A01.

Paper presented at 87th meeting of the Italian Electrotechnical Association (Florence, 28 Sep-3 Oct 1986).

The article presents the guidelines of the work plan which has the aim of rationalizing the approach to the solution of problems connected with the management of the low, medium and high voltage networks. The principal scope of the activities is to obtain a short term economy of resources and implement a coherent approach for the planning of the future development of the network such that significant reductions in energy would be achieved together with increased reliability and operating safety. The fundamental points regard the study of the network, the diagnostic plan, the revision of technical specifications for the standardization and classification of principal electrical components. The article underlines the fact that only by the application of a global and systematic approach to network problems, it is possible to obtain tangible and economically significant results.

7604 (CRIE–8901) **Prevention of thunder hazard of power facilities. Result of study and the future problems of winter thunder.** Central Research Inst. of Electric Power Industry, Komae, Tokyo (Japan). Energy and Environment Lab. 31 Jan 1989. 71p. (In Japanese). Order Number DE89910219. Available from NTIS (US Sales Only), PC A04/MF A01.

This booklet is a Jan. issue (1989) of Denchuken (Central Power Research Institute) Review, and contains the following items. 1. Introduction. 2. Accidents of power transmission lines by thunder. 3. Winter thunders (Method of observation) Thunder shock on high structures. Winter thunder discharge phenomena. Prediction of winter thunder. 4. Causes for simultaneous accident of dual circuits by thunder. (Thunder shielding Propagation characteristics of thunder surge. Flashover of insulator device. Study of causes of simultaneous accidents of dual circuits). 5. Method of predicting the rate of thunder accident. 6. Measures of preventing the thunder accident (Flash-over prevention. Effect of thunder accident prevention. Measures for the winter thunder). 7. Future problems (Predicting method of corona attenuation and strain charge of thunder surge) Establishment of calculating method considering the time characteristics applicable to big current at iron-tower potential increase. Clarifying the flash-over characteristics considering the multi-phase simultaneous discharge of the insulator device, etc. 33 refs., 48 figs., 7 tabs.

7605 (CRIE-W–88003) **Calculation method of temperature rise-of outdoor type molded transformers.** Takahashi, Tsuyoshi; Kato, Masao; Sato, Masahiko; Hozumi, Naoyuki; Higashihara, Takashi; Hasegawa, Takashi. Central Research Inst. of Electric Power Industry, Tokyo (Japan). Oct 1988. 31p. (In Japanese). Order Number DE89910303. Available from NTIS (US Sales Only), PC A03/MF A01.

It is necessary to grasp the temperature of high tension coil to clarify the thermally deteriorating characteristics of coil insulation in molded transformers containing epoxy resin. This report proposed the estimating method of high tension coil temperature rise difficult to measure with the thermal equivalent circuit and investigated the coil temperature characteristics under the natural condition from the wind cooling test for the transformer coil. A model where the molded transformer of structure separated to high tension coil and low tension coil was horizontally cut in round slices, was assumed and the temperature rise was calculated with the proposed method to verify that the calculation agreed well with the experimental results at no wind. On the basis of the wind cooling effect determined for the molded transformer under the constant wind speed, the continuous loading test was carried out, aiming 145C rise at the outdoor. On the basis of temperature control by changing the loaded current for the temperature variation, the equivalent thermal deterioration temperature of the transformer became 125C, so that the transformer could be operated at 20C lower temperature than the maximum one. 6 refs., 22 figs., 3 tabs.

7606 (EFI-TR–3507) **Atmospheric icing of transmission lines.** Ervik, M.; Fikke, S.M.; Finstad, K.J.; Carstens, T. Elektrisitetsforsyningens Forskningsinstitutt, Trondheim (Norway). Apr 1989. 169p. Order Number DE90728215. Available from NTIS (US Sales Only), PC A08/MF A01.

The report describes a deterministic model for in-cloud ice accretion on suspended cables, accounting also for the torsional stiffness of the cable. The model is compared with the EFI model developed by The Norwegian Research Institute of Electricity Supply with respect to the magnitude of its input parameters. A field program is started for model testing. Earlier Norwegian icing data are also reviewed. 13 refs., 10 figs., 16 tabs.

7607 (EPRI-EL–6592) **Substation control and protection project: System requirements specifications: Final report.** Deliyannides, J.S. (Westinghouse Electric Corp., East Pittsburgh, PA (USA)). Electric Power Research Inst., Palo Alto, CA (USA); Westinghouse Electric Corp., East Pittsburgh, PA (USA). c Nov 1989. 141p. Sponsored by Electric Power Research Institute. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

This specification was developed during Phase I of EPRI Project RP1359-1 and was published as EL-1813 in April of 1983. This project involves the design and implementation of a microprocessor-based, integrated protection, and control system for transmission class substations. In order to define the scope of the system, a list of possible functions was generated and the requirements for each function were defined after extensive consultation with Host Utility personnel and with other Utility Advisors. A list of general system requirements and design criteria was also generated. This specification served as the starting point for the development of detailed functional specifications and subsequent implementation specifications. The requirements were the design goals whose feasibility and practicality were tested for those functions chosen during the design, implementation, and demonstration phases of the project. This report updates the earlier report through revisions and additions. The changes reflect added knowledge gained during the latter stages of the project.

7608 (EPRI-EL–6594) **Sustation control and protection project: Communication interface specification.** Electric Power Research Inst., Palo Alto, CA (USA); Westinghouse Electric Corp., Pittsburgh, PA (USA). c Nov 1989. 75p. Sponsored by Electric Power Research Institute. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

This communication interface specification was developed during Phase I of EPRI Project RP 1359-1 and continued to evolve during Project RP 1359-7. The project concerns the design and implementation of a microprocessor-based, integrated protection and control system for transmission class substations. The various elements of the system are arranged in a hierarchy. This specifications defines the interfaces between the various levels of hierarchy. The need for a well-defined, standard interface specification becomes more apparent when considering the fact that different manufactures may be supplying equipment within the same substation. The specification considers each level of the hierarchy and defines the physical characteristics, the signal characteristics, the hardware and message protocol, the message framing and the user level data structures for each interface. 10 figs.

7609 (ETDE-mf–9761949) **Electric distribution network planning: criteria and models for the optimization of reactive power generation.** Innorta, M.; Marannino, P.; Martocchia, C.; Nevaloro, S. Ente Nazionale per l'Energia Elettrica, Milan (Italy). 1986. 9p. (In Italian). Order Number DE89761949. Available from NTIS (US Sales Only), PC A02/MF A01.

The paper presents the ENEL (Italian National Electricity Board) automatic procedure BACONE for the formulation of capacitor bank installation programs for reactive power compensation. It is based on a Han-Powell derived algorithm. The apporach, relative to the problem of network constrained power control, is essentially to optimize the investment in additional equipment while taking into account the requirement of having admissible voltage profiles for both transmission and production systems in normal operating conditions and in the presence of partial breakdowns.

7610 (IEEJ–8902) **1989 National convention record I. E. E. Japan (part 8).** Institute of Electrical Engineers of Japan, Tokyo (Japan). Apr 1989. 328p. (In Japanese). Order Number DE89910081. Available from NTIS (US Sales Only), PC A15/MF A01.

From presented articles of the National convention, I. E. E. Japan opened in April, 1989, the articles of the electric power system section are recorded. The section includes 203 articles: Load frequency control by compensation-limited type controller. Robust control of hydraulic power station, Introduction of local FFC control, Study on application of on-load tap changers to frequency control, Design of adaptive load frequency control, Digitally redesigned LFC in consideration of GRC, Application of follow-up control with variable structure model to power systems, Calculation of demand and supply balance control by LP method, Coordination between ELD and LFC based on optimal control theory, Decentralized control of large scale power systems by disturbance observer and integrating optimal servo system, Self-decentralizing system of power systems by coherent group and others. 386 refs., 571 figs., 79 tabs.

7611 (OH/RD–88-161-K) **Circuit braker diagnostics by vibration monitoring.** Mader, D.L. Ontario Hydro Research Div., Toronto, ON (Canada). 26 Oct 1988. 15p. (MICROLOG–89-04320). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

The feasibility of circuit breaker diagnosis with vibration monitoring has been indicated by vibration signature recordings taken on a breaker before and after rehabilitation maintenance. Slight changes are evident in the timing of events and in the level of vibration, showing that valuable mechanical information is present in the signature. Analysis methods are discussed. A description is also provided of the data aquisition system used in these tests. A listing of the data acquisition and analysis programs is included. 3 refs., 9 figs.

7612 (OH/RD–88-216-K) **Surge voltage investigation at the Moore farm.** Lat, M.V. Ontario Hydro Research Div., Toronto, ON (Canada). 4 Nov 1988. 9p. (MICROLOG–89-04585). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

A monitoring study of transient voltages in the electrical system of a dairy farm has been carried out. The study was primarily aimed at recording transients in the ground system that could appear as a touch potential in the cow barn. The recorded waveshapes do not indicate any abnormal transient voltages that could cause livestock problems. The possibility that transient voltages could cause the failure of the bulbs or of a well pump was also excluded. 4 figs., 2 tabs.

7613 (OH/RD–88-231-K) **Northeastern region 25 Hz system test.** Berube, G.R. Ontario Hydro Research Div., Toronto, ON (Canada). 23 Sep 1988. 59p. (MICROLOG–89-04436). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

Dynamic stability and motor starting tests were performed on the Northeastern region (Ontario) 25 Hz system to assess the impact of the removal of the 115 kV interconnection to Hydro Quebec. The tests showed that the interconnection has little effect on the system's dynamic stability and voltage support characteristics. The system exhibited a positive damping for the prevalent low frequency mode of oscillation for each of the tested configurations. Voltage decline readings taken at various stations on the system, during the starting of the Kerr Addison mines hoist motor, were within acceptable limits under all tested conditions. Detailed computerized dynamic models of the Abitibi Canyon G1 excitation and governing systems are provided for use in digital studies of planning and operation. 4 refs., 36 figs., 5 tabs.

7614 (OH/RD–88-271-K) **Port Hope TS [transmission station]: Grounding studies.** Pillai, R.P. Ontario Hydro Research Div., Toronto, ON (Canada). 16 Nov 1988. 16p. (MICROLOG–89-04316). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

Tests were conducted at Port Hope, Ontario, transmission station under simulated fault conditions in order to evaluate the grounding system performance at the station. The resistivity of the soil at the station was also tested. Models were developed to generalize the results. The measured and modelled station ground potential rise and touch and step potentials for a maximum high voltage fault current of 2.5 kA were found to be within safe limits. Preliminary calculations indicated that the station ground potential rise for an estimated low voltage fault current of 6.5 kA can exceed that allowable limit of 5 kV. 4 refs., 2 figs., 5 tabs.

7615 (OH/RD–88-304-K) **Reliability assessment of the power supply for the Clarkson system control center.** Ramani, N. Ontario Hydro Research Div., Toronto, ON (Canada). 13 Dec 1988. 26p. (MICROLOG–89-04582). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

Ontario Hydro plans to move the System Control Center (SCC) to a new location at Clarkson by the year 1991. The Operations Research Department is taking part in the reliability evaluation of the new facilities. The current study forms a part of the investigation and examines the reliability of the power supply to the Control Center. A reliability assessment of the power supply for the new electric power system control center at Clarkson has been carried out. The mean times between outages, the mean times to restore service, and the probabilities of interruption of power supply at various load points in the control center have been estimated and are used as the reliability indices. These values were examined by personnel from the relocation project team and judged to be acceptable. 4 refs., 3 figs., 11 tabs.

7616 (OH/RD–89-11K) **Investiation of 15 kV air-magnetic breaker failures.** Narang, A. Ontario Hydro Research Div., Toronto, ON (Canada). 18 Jan 1989. 10p. (MICROLOG–89-04308). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

Recent failures of feeder breakers at Lake Transformer Station (TS) and Birmingham TS during periods of lightning activity were investigated. No evidence of a breaker malfunction was found. The switching duty for conventional faults has been assessed and is expected to have been within breaker ratings. It is postulated, on the basis of circumstantial evidence, that the breakers failed due to evolving faults associated with lightning activity. A recent failure of an Ottawa Hydro owned air-magnetic breaker was also reviewed because of its possible relevance to the Ontario Hydro failures. This breaker failed on a closing operation, but it is possible that it had been damaged during earlier switching operations. As a consequence of this investigation, concerns have been identified regarding possible deficiencies in existing circuit breaker standards. However, these are not considered a factor in these failures. 20 refs.

7617 (OH/RD–89-26-K) **Developments in XLPE-[cross linked polyethylene] insulated underground distribution cable.** Mintz, J.D. Ontario Hydro Research Div., Toronto, ON (Canada). 21 Feb 1989. 39p. (MICROLOG–89-04298). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

This report examines the current status of Cross-Linked Polyethylene-insulated power cables, and the new designs that are being offered. The methods for testing the cables in the laboratory and in the field and the control of quality in manufacturing are discussed. As well as using the information available on in-service cable performance to estimate the life of older cable designs, a conservative estimate is derived for the expected life of current cable designs and new optional designs based on the present understanding of failure modes in medium voltage power cables. An examination of current cable standards is presented and recommendations for changes are made, especially to incorporate the effect of these new cable designs on cable specifications. 6 refs., 1 fig., 22 tabs.

7618 (OH/RD–89-38-K) **Frost heave monitoring results at selected transformer stations: Winter 1987/88.** Vorauer, A. Ontario Hydro Research Div., Toronto, ON (Canada). 10 Feb 1989. 18p. (MICROLOG–89-04302). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

Several transformer stations have reported heaving of light equipment foundations. To assess remedial designs, four types of test footings were installed and monitored at Port Hope Transformer Station (TS), Ottawa-Hawthorne TS, and Pinard TS. Results of a second year of field monitoring indicate that the winter of 1987-88 was warmer than normal in southern Ontario, leading to less frost penetration and ground heave. In northern regions, temperatures were generally normal; however, an increased snow cover protected the soil from extensive frost penetration. This phenomenon is examined by application of the Bergreen equation that estimates frost depth. It is recommended that field monitoring be discontinued for the present and that emphasis be placed on controlled testing of footing heave in the laboratory. 6 refs., 6 figs., 3 tabs.

7619 (ORNL/FTR–3463) **[Engineering standards in the CARES [Central American Rural Electrification Support] project]: Foreign trip report, October 15–October 26, 1989.** Garcia, A. III. Oak Ridge National Lab., TN (USA). 27 Oct 1989. 5p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90003201. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Given the short time that the staff has been in place the overall progress has been exceptional. No doubt the professionalism and high level of technical competence of the staff are some of the primary reasons. Documentation of the projects is adequate to reconstruct events and information that result in key decisions. The current Annual Workplan, however, is cumbersome due to its organization and excess of redundant reporting. It needs to be reorganized based on the original goals of the Phase I Study and not the 35 components. The progress to date has been impressive. The NRECS Staff has made a significant impact on policy and engineering decisions in Belize, Guatemala and El Salvador, all with some proven cost savings. The demonstration projects and alternative designs have resulted in a high degree of credibility for the NRECA Staff. The proposed new engineering standards have gained acceptance in all of the countries as experience grows. They are well planned and carefully thought out. Professional training will be needed in the coming years to overcome the natural momentum of the status quo.

7620 (ORNL/Sub–85-22005/1) **Integrated hierarchical computer systems for adaptive protective relaying and control of electric transmission power systems.** Phadke, A.G. (Virginia Polytechnic Inst. and State Univ., Blacksburg, VA (USA)); Horowitz, S.H.; Thorp, J.S. Oak Ridge National Lab., TN (USA); Virginia Polytechnic Inst. and State Univ., Blacksburg, VA (USA). Nov 1989. 125p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC05-84OR21400. Order Number DE90004370. Available from NTIS, PC A07/MF A01 - OSTI; GPO Dep.

The report examines current protection practices on electric power transmission networks, their limitations, and the restrictions placed upon the protective systems by the current state of the technology. The field of digital computer based relaying is reviewed, and it is shown that computer relays with communication capability offer a substantial opportunity to change many aspects of relay systems for the better. In particular, the relay systems can be made responsive to changes taking place in the power system. This concept is labeled "Adaptive Relaying," whereby relays and protective systems adapt themselves to changing power system condition. Several opportunities for adaptive relaying are revealed. In each case a technological assessment of the needs and feasibility of the adaptive approach is made. Impact of failures of the adaptive features on the system as a whole is discussed. Safe fall-back positions are discussed. Also considered are coordination aspects of adaptive and non-adaptive relaying functions within the same system. The report concludes with a conclusions section which includes a look at the directions for future research in this field. 43 refs., 17 figs., 1 tab.

2403 Power Transmission Lines and Cables

Refer also to citation(s) 7601, 7823

7621 (NBU/ME–180D579) **Development of an influence vector for the electrical coordination of power and telecommunications systems.** Hill, E.F. (Univ. of New Brunswick, Fredericton, NB (Canada)); Smolinski, W.J.; Sharaf, A.M.; Tranquilla, J.M. New Brunswick Univ., Fredericton, NB (Canada). Dept. of Mechanical Engineering. Aug 1989. 125p. (CE–02804). Available from Canadian Electrical Association, Research & Development, Suite 500, One Westmount Square, Montreal, PQ, CAN H3Z 2P9. Prices: $75.00 NON-MEMBERS; MEMBERS: PRICES UPON REQUEST FUNDS CAN.

An examination of the generalized, scientific principles of, and basis for, an influence vector for the electrical co-ordination of power and telecommunications systems is reported. The influence vector has been defined as the minimal parameter set on which information needs to be obtained and exchanged by the power and telecommunication utilities in order to resolve inductive coordination problems during transmission on adjacent lines. The influence vector consists of two types, inductive and conductive. Each of these has been examined to establish important parameters. Discussed are methods of quantifying the influence vector, the nature of the coupling between power lined and adjacent telecommunications lines, and problems with measurement versus calculation of the influence ector. Among other recommendations, additional data sets should be added to system load databases, and projects should be structured to gather all statistical data on distribution system faults. 28 refs., 15 figs., 10 tabs.

7622 (OH/RD–88-183-K) **Transmission line refurbishment study: Tower foundation inspection and testing. Smith Falls to Kingston - 115 kV TL CCT S1K.** Tsang, R.H.K.; Radhakrishna, H.S. Ontario Hydro Research Div., Toronto, ON (Canada). 3 Nov 1988. 96p. (MICROLOG–89-04579). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

As part of the preliminary transmission line refurbishment study, an inspection and field load testing of foundations was conducted for Kingston type towers along a section of 115 kV Kingsto-type suspension towers from Smith Falls to Kingston. The foundations were assessed for their condition, rate of aging, and load capacity. The results of visual inspection, geotechnical investigation, and field load tests of earth grillages and rock anchors are presented in this report. The mechanical properties of native soil and backfill are compared. The variability associated with the foundation condition, corrosion of steel, and load capacity are discussed. Factors contributing to the variability of the load capacity of foundations are highlighted. The foundation integrity and capacity are assessed based on the results of this study. 7 refs., 35 figs., 13 tabs.

7623 (OH/RD–88-270-K) **Foundation corrosion survey. Circuit L22H (Eastern region): Preliminary report.** Vorauer, A.; Radhakrishna, H.S. Ontario Hydro Research Div., Toronto, ON (Canada). 8 Nov 1988. 21p. (MICROLOG–89-04306). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

A corrosion survey of transmission tower footings was undertaken along a portion of circuit L22H, a 230 kV transmission line in Ontario's eastern region. The survey included measurements of leg-to-soil potentials and corrosion currents using a Tower Leg Integrity Monitor (TLIM 100). Soil samples were taken for laboratory measurements of soil resistivity, pH, and sulfur content. Current readings on sacrificial anode systems were also made using a clip-on ammeter. It was concluded that both circuit and potential measurements will give a more complete picture of underground corrosion activity and that the TLIM 100 is a simple instrument to use on a routine basis. The measurement of specific soil parameters in the laboratory may help to identify certain soil conditions that may promote corrosion activity, but to date these parameters do not exhibit good correlation with in-situ electrical measurements. 6 refs., 11 figs., 3 tabs.

7624 (OH/RD–89-45-K) **Line refurbishment program.** Ewing, H.A. Ontario Hydro Research Div., Toronto, ON (Canada). 6 Feb 1989. 12p. (MICROLOG–89-04301). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

A program for the long-term planning of transmission line refurbishment was initiated. This report summarizes the tests, and their results to date, for the portion of the program covering the conductors, insulators, and line hardware. The conclusions were that conductors would be the primary concern, that conductors with in-service dates prior to 1940 and with known high contamination areas had to be tested, that, according to initial results, age is only one of many factors affecting the service life of conductors, and that the corrosion of the steel core wires is the most common cause of loss of conductor strength. Recommendations are given for improving the usefulness of the data obtained and the manner in which conductor samples are selected. 4 refs., 3 tabs.

7625 (SAND–89-2733C) **Theoretical and experimental investigation of axial power extraction from a magnetically insulated transmission line oscillator.** Lemke, R.W. (Sandia National Labs., Albuquerque, NM (USA)); DeMuth, G.E.; Biggs, A.W. Sandia National Labs., Albuquerque, NM (USA). [1989]. 10p. Sponsored by U.S. Department of Defense. DOE Contract AC04-76DP00789. (CONF-900140–1: SPIE optics, electro-optics and laser applications in science and engineering conference and exhibition, Los Angeles, CA (USA), 20-25 Jan 1990). Order Number DE90003486. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The utility of the magnetically insulated transmission line oscillator (MILO) as a high power microwave source depends on how efficiently power can be extracted from it. We have designed a slow-wave stepped transformer for the purpose of axially extracting microwave power from a 3.6 GHz coaxial MILO. The slow-wave transformer design was optimized using particle-in-cell simulation, and tested in experiments performed on the HPM Simulation Division's GEMINI and GYPSY water Blumlein pulse power sources. In this paper we summarize the slow-wave stepped transformer design, and describe MILO axial power extraction experiments which yielded up to 300 MW of radiated power. 10 refs., 4 figs., 2 tabs.

7626 (STU–81-4243) **Temperature measurement in power transmission cables.** Arnfjorden, J. (Intab Interface-Teknik AB, Partille (SE)). Swedish National Board for Technical Development, Stockholm (Sweden). [1989]. 46p. (In Swedish). Order Number DE90728274. Available from NTIS (US Sales Only), PC A03/MF A01.

The load capability of electrical cables depends on maximum tolerable temperature. Exact knowledge of the temperature makes reduction of safety margins in cable design possible and perhaps saving of investments in enlargement of certain networks. The aim of the project was design of a probe that could be attached to current-carrying high voltage power transmission cables. The probe should measure cable temperature, ambient temperature, and the current. The measured values should be transmitted to a ground-based receiver unit. The work resulted in a manufacturable functioning unit. It has been tested in the field with very good results. It is now possible to eliminate conjecture from the load calculations. In future a possibility opens to utilize the actual measured values via computer to control the load on a power network.

2404 Health and Safety

Refer also to citation(s) 8597

2405 Environmental Aspects

Refer also to citation(s) 8597

2406 Legislation and Regulations

Refer also to citation(s) 7753

2407 Economic, Industrial, and Business Aspects

Refer also to citation(s) 7463, 7743, 7753

25 ENERGY STORAGE

2502 Compressed and Liquefied Gas

Refer also to citation(s) 6891

7627 (STU–88-3749) **Industry applications for LNG.** Holmstroem, T. (EnergiPlanerarna AB i Stockholm (SE)); Traenkle, S.; Sedlacek, A. Swedish National Board for Technical Development, Stockholm (Sweden). 30 Mar 1989. 26p. (In Swedish). Order Number DE90728279. Available from NTIS (US Sales Only), PC A03/MF A01.

Industry applications of LNG-cold are reviewed. Technical designs and some economic data for existing foreign LNG-cold plants are reported.

2504 Capacitor Banks

7628 (OH/RD–88-239-K) **Review of capacitor switching effects on power quality.** Dick, E.P. Ontario Hydro Research Div., Toronto, ON (Canada). 11 Oct 1988. 7p. (MICROLOG–89-04560). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

This review report shows that capacitor switching surges are generally modest in level compared to other transients seen by electrical customers due to load switching, lightning, or system faults. However, capacitor switching may be responsible for the following particular stresses. Firstly, the daily switching of capacitors can lead to the failure of deteriorating equipment, since other sources of surges may be less frequent. Secondly, the duration of capacitor switching transients could be long enough (up to several milliseconds) to thermally overload surge protectors, installed to limit microsecond duration surges. Thirdly, the fast voltage dip associated with energizing an uncharged capacitor bank may prevent thyristor firing, thus causing a variable speed drive to trip. The second and third areas do not appear to be well addressed by current standards and are covered by only a small number of technical references. 11 refs.

2506 Thermal

Refer also to citation(s) 7223

2508 Chemical

Refer also to citation(s) 7794

7629 (RISO-M–2608) **Chemical energy storage based on metal hydrides: Main report.** Vigeholm, B. Risoe National Lab., Roskilde (Denmark). Apr 1989. 104p. (In Danish). Contract EM-22632;Contract EM-22632-1;Contract EM-2263-306. Order Number DE90728133. Available from NTIS (US Sales Only), PC A06/MF A01.

EFP-80; EFP-81; EFP-83.

With financial support from the reserch programmes established by the Danish Minestry of Energy we have in the years from 1980 to 1986 investigated the possibility of using magesium hydride as load levelling storages for variable energy sources like windmills. The investigations reported here comprise evaluations of thermodynamic, kinetic and mechanical relations for various materials and the construction and testing of a 2 kWh storage plant. Our conclusion is that a storage based on absorption of hydrogen in magnesium powder will function at 85% efficiency in terms of capacity at a cycling rate suitable for a load levelling storage and with a lifetime of several thousand cycles. An economical evaluation is rather uncertain, as some prices are unavailable and the effect of different operational modes insufficiantly described. An attempt to make some assesments is made. (author) 13 tabs., 71 ills., 21 refs.

7630 (RISO-M–2608(app.3)) **Chemical energy storage based on metal hydrides: Appendix 3. Detailed information on important facilities and equipments.** Vigeholm, B. Risoe National Lab., Roskilde (Denmark). Apr 1989. 45p. (In Danish). Contract EM-22632;Contract EM-22632-1;Contract EM-2263-306. Order Number DE90728165. Available from NTIS (US Sales Only), PC A03/MF A01.

EFP-80; EFP-81; EFP-83.

This appendix gives detailed information on the most important experimental facilities and equipments utilized during the project. The descriptions are intended to be given on the level of detail insight, that we had to have in order to use the facilities in a qualified way. In those cases, where existing manuals were available, we refer to those. (author) 5 tabs., 76 ills.

7631 (RISO-M–2608(app.4)) **Chemical energy storage based on metal hydrides: Appendix 4. Experimental data for 2 kWh storage system.** Vigeholm, B. Risoe National Lab., Roskilde (Denmark). Apr 1989. 55p. (In Danish). Contract EM-22632;Contract EM-22632-1;Contract EM-2263-306. Order Number DE90728166. Available from NTIS (US Sales Only), PC A04/MF A01.

EFP-80; EFP-81; EFP-83.

This appendix gives the most significant experimental data from the experiments done with the constructed 2 kWh storage system. The data are presented in a number of different, self-explanating ways. (author) 96 ills.

7632 (RISO-M–2608(app.5)) **Chemical energy storage based on metal hydrides: Appendix 5. Publications.** Vigeholm, B. Risoe National Lab., Roskilde (Denmark). Apr 1989. 151p. (In Danish). Contract EM-22632;Contract EM-22632-1;Contract EM-2263-306. Order Number DE90728167. Available from NTIS (US Sales Only), PC A08/MF A01.

EFP-80; EFP-81; EFP-83.

During the supported project a number of detailed investigations have been presented at international conferences, in the specialized literature or in popular form in technical periodicals etc. The relevant articles are reprinted in this appendix in the original form and in cronological order. (author) 17 tabs., 155 ills., 99 refs.

2509 Batteries

Refer also to citation(s) 7191, 7869

7633 (BNL–43460) **Flow batteries: Present status and research areas.** McBreen, J. Brookhaven National Lab., Upton, NY (USA). [1987]. 11p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-871027–48: 172. meeting of the Electrochemical Society, Honolulu, HI (USA), 18-23 Oct 1987). Order Number DE90003968. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Many of the new batteries considered for large scale energy storage are flow batteries. These batteries are attractive because of the initial low cost of the reactants and cell components. Other important characteristics are ease of maintenance and control. As a result, work on flow batteries continues mostly in the USA and Japan. Recent developments and research areas are reviewed. 46 refs.

7634 (DOE/NV/10672–1) **Evaluation of a new charge algorithm for a lead-acid battery with gelled electrolyte using a 96V gel cell IV as a test battery: Final report for FY-1988.** Nowak, D.K. (Alabama Univ., Huntsville, AL (USA). Kenneth E. Johnson Research Center). EG and G Idaho, Inc., Idaho Falls, ID (USA); Alabama Univ., Huntsville, AL (USA). Kenneth E. Johnson Research Center. Oct 1989. 46p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract FG08-87NV10672. Order Number DE90003420. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This document has reported a summary of test results obtained utilizing the new UAH charge algorithm for Lead-Acid batteries with gelled electrolyte. The battery performance data for a 96V Phase IV Gel/Cell battery pack was tested in a Jet Industries Electrica vehicle. It was shown that the new charge concept is sound although there can be problems with batteries that are highly imbalanced and where excessive electronic noise is experienced on the electronic signal feed-back line that carries the voltage sensor signals from the battery. Additional work is needed to add intelligence to the charge algorithm in terms of a better ability to extract the beginning of gas development from the voltage spread function. This can probably be accomplished by scanning the voltages more often and including that data into the function analysis by adding software filters. The Phase IV Gel/Cell battery performance was found to be about 20% lower than that of the Phase III Gel/Cell battery. Problems with cell valve leakage were encountered in the Phase IV Gel/Cell that pose a threat to battery life although so far no battery module has been lost. 2 refs., 13 figs., 4 tabs.

7635 (NEI-DK–241) **Testing methods for battery systems for wind turbine and solar cell energy systems.** Nissen, O.S.; Amdi Petersen, H. Energilaboratoriet, Odense (Denmark). Aug 1989. 80p. (In Danish). Order Number DE90728154. Available from NTIS (US Sales Only), PC A05/MF A01.

The aim was to develop testing equipment and a method of testing which could be helpful when selecting batteries to be used in relation to solar cell systems and wind turbines. Such batteries guarantee a consistant production of electric power. Methods of coordinating the aging process of the battery with the character of the renewable energy system and the characterization of the various aging stages of the battery are described. The testing equipment consists of a computerized system dealing with battery charging and capacity which, on the basis of registered charging and capacity data, controls, monitors and documents the testing process. The design of each type of battery is described in detail and test results are presented. (AB).

7636 (SAND–89-2214C) **A nickel/hydrogen battery for PV systems.** Bush, D.M. Sandia National Labs., Albuquerque, NM (USA). 1990. 11p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC04-76DP00789. (CONF-900138–1: 5. annual battery conference on applications and advances, Long Beach, CA (USA), 16-18 Jan 1990). Order Number DE90001537. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The nickel/hydrogen battery was developed in the early nineteen-seventies as an energy storage subsystem for commercial communication satellites. The advantages offered by nickel/hydrogen batteries, including long life, low maintenance and high reliability, make it very attractive for terrestrial applications such as stand-alone photovoltaic systems. The major drawback to the wider use of the nickel/hydrogen battery is its high initial cost. Sandia National Laboratories has placed cost-shared contracts with Comsat Laboratories and Johnson Controls, Inc., to reduce the cost, and a battery consisting of prismatic cells in a common pressure vessel has evolved. A 7-kWh battery has been on test at Sandia since January 1988 using a flat-plate photovoltaic array for charging. 4 refs., 4 figs., 2 tabs.

7637 (SAND–89-2312C) **Fault tree analysis: A tool for battery safety and reliability studies.** Levy, S.C. Sandia National Labs., Albuquerque, NM (USA). [1989]. 7p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC04-76DP00789. (CONF-900138–2: 5. annual battery conference on applications and advances, Long Beach, CA (USA), 16-18 Jan 1990). Order Number DE90002582. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Fault tree analysis has been used by engineers as a means of defining system failure. It provides a method of system examination which increases the level of understanding of the system and is helpful in logically determining the underlying causes of potential failures. A fault tree is composed of a number of symbols, describing different types of events, which are operated on by logic gates. Construction of a battery fault tree is discussed in terms of two types of event and two logic gates. An example is given of how fault tree analysis was used to determine the cause of a safety incident. A string of lithium cells on test for several years suddenly vented violently. Fault tree analysis quickly pointed out the underlying faults leading to this event, and a means of prevention was suggested. 1 ref., 3 figs.

29 ENERGY PLANNING AND POLICY

7638 (CANWEC–CE-02827, pp. 19) **Looking towards the next century: Major themes in energy: Report 1.1.10.** . Leydon, K.; Neto, J.C.; Camos, M.; Deimezis, N.; Taylor, D. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02827). In *Energy for tomorrow. Division 1: Energy and society: Session 1.1: Social implications of energy supply.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

In response to continuing economic growth, further stimulated by the opening up of the internal market, the European Community energy consumption is expected to grow steadily over the next two decades. This growth in final energy demand will occur in all sectors, industry, transport, residential and agriculture and will benefit all fuel types. This paper looks at the forecast evolution of energy demand in the Community over the next twenty years with special reference to two important sectors: transport, and electricity. It then views community requirements in a global context. Finally it looks also at the relationship between energy needs and the environment. Europe will increase its dependence on imported fuels. These are already 50% of primary energy consumption and are expected to increase slowly but steadily through out the next decades. Fuel supply will constrain energy consumption. The world's resources of fuels are sufficient to cover any foreseable demands until well beyond the period under review. A diversification of supply and variety of fuels, together with improved trade relations, should help to reduce risks of interruptions to primary energy supplies. Supply security must be closely monitored. Environmental issues are starting to dominate energy discussions and will become increasingly important in decisions on energy policies. Technology can improve the efficiency with which we produce and use energy, but these improvements will be more than offset by increasing energy consumption.

7639 (CANWEC–CE-02827, pp. 21) **Strategic energy challenges of developing countries: A systematization for effective planning: Report 1.1.9.** . Del Valle, A. (Univ. Catolica de Chile (Chile)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02827). In *Energy for tomorrow. Division 1: Energy and society: Session 1.1.: Social implications of energy supply.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Several major questions must be addressed at the first stage of energy planning in developing countries. These are: how should the strategic energy challenges be identified in develping countries; how do they differ for politicians, economists, technologists, the supplying companies or the users of energy; are the current energy plans solving the right problems or are there some crucial ones not well identified, and thus not being acted upon. This paper will present a systematic way of raising the mentioned questions, identifying the main strategic energy challenges that a developing society is facing, and giving guidance to energy planning and policy making. It deals in an integrated fashion with the four basic lines of action that any society has available in the energy field: supply of energy, use of energy, energy resources and energy technology. It also deals with the central objectives of the development process: self-reliance of society, quality of life of its population and sustainability on its own resources. The paper is based on a five-year research effort on energy planning in developing countries, carried out at the Energy Research Programme of Universidad de Chile (PRIEN), and at Universidad Catolica de Chile, and financed chiefly by the International Development Research Centre (IDRC) of Canada. Thirteen strategic challenges for developing countries are presented. Self-reliance and increased living standards of a developing country can be improved by acknowledging and meeting these challenges, not by the current of practise of maintaining continuity of existing policies. 10 refs., 1 tab.

7640 (CANWEC–CE-02828) **Energy for tomorrow. Division 1: Energy and society: Session 1.2: Planning to meet society's future needs.** Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. VP (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02828). Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This session focussed on the plans, policies, management strategies and research efforts applied in a variety of countries designed to enable them to develop and commercialize an energy infrastructure which can simultaneously meet the needs of industry, citizens and the environment in the future. Most presentations dealt with the experience of individual countries, although some papers focussed with application of specific technologies, economic modelling and international cooperation. Separate abstracts were prepared for 32 papers.

7641 (CANWEC–CE-02829) **Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.** L'energie pour demain. Division 1: L'energie et la societe. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. vp (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This session deals with the role of society in energy decision-making focusing especially on the energy policy of developed and developing countries, and the role of public opinion in the formulation of such policies. Separate abstracts have been prepared for 14 papers.

7642 (CANWEC–CE-02829, pp. 14) **Using energy scenarios for policy purposes: A case study for the Netherlands: Report 1.3.8.** . Bruggink, J.J.C. (Netherlands Energy Research Foundation (Netherlands)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper forecasts performance of the Dutch energy sector up to the year 2010. This study is based on a set of three long-run economic scenarios developed by the Central Bureau of Planning. For each of these scenarios three policy cases are developed representing different decisions with respect to fuel diversification. The goal of the National Energy Outlook was to provide policy makers with strategic information for policy purposes through an analysis of the economic and environmental consequences of the different scenarios and cases. In the report, the fuel and technology mix is described with emphasis on the mutual interdependencies between public and private decisions. The environmental consequences of

all the scenarios appear to be dramatic when present policies remain unchanged. Finally, some new developments and their impact on the present study are mentioned. 6 gis., 3 refs.

7643 (CANWEC–CE-02829, pp. 32) **The high cost of misunderstanding OPEC [Organization of the Petroleum Exporting Countries]: Report 1.3.10. .** Takin, M. (Organization of the Petroleum Exporting Countries). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper traces the history of the world oil industry since 1940s and the formation of the Organization of Petroleum Exporting Countries [OPEC]. The impact of three oil shocks of 1973, 1979 and 1986 on oil exporting and oil importing countries are discussed. The author then describes the hostility which characterised the consuming countries' attitude towards OPEC and their initiatives to reduce dependence on OPEC oil at all costs. In some countries these policies assumed the importance of national strategy. Energy conservation programmes were hastily drawn up, some countries began investing huge sums in oil exploration and production. As a result of these measures, overall energy demand fell, resulting in a dramatic fall in oil prices. The paper further argues that sometimes these developments became investment traps. The large scale projects, involving heavy capital expenditures, and long lead time, were mostly inflexible and incapable of being adapted to changing market conditions. The time has shown, both producers and consumers have suffered from the price fluctuations, whether upwards or downwards. The author concludes by maintaining that durable oil market stability cannot be achieved without OPEC and that other oil producers should assume their share of the responsibility for supporting the market. Mutual trust and co-operation among all producers and also between producers and consumers is called for. 67 refs.

7644 (CANWEC–CE-02834-3.2) **Energy for tomorrow. Division 3: Energy and the economy: Session 3.2: Major economic influences on energy.** Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. vp (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02834). Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This session examined the relationship between energy and economic strength with reference to the experience of particular countries. Papers are presented by the USSR, Bulgaria, Hungary, Yugoslavia, Japan, Korea, Italy and France. Aspects of electrical energy and natural gas were detailed including historical aspects and proposals for revised energy policies. Separate abstracts have been prepared for 18 papers.

7645 (IEE-SR–205) **Analysis of competition among the kinds of energy at the era of complexed energy.(General review).** Institute of Energy Economics, Tokyo (Japan). 31 Dec 1989. 125p. (In Japanese). Order Number DE89910215. Available from NTIS (US Sales Only), PC A06/MF A01.

Present situation of competition among kinds of energy was analyzed, and concerning energy industries and national policy for energy at the era of complexed energy, review and possibility of progress were explained under the guiding principle of fair competition among the kinds of energy. Energy industries were classified into petroleum, town gas, and electricity. It was explained that decisive factors of competition among them were not only purchasing price but characteristics of application equipment. Problems involved in them were discussed. Competitive feature in the fields of industry and public welfare was explained in detail with review on future. National policy for energy was discussed from the view points of holding of security, cost reduction, and adaptation to demands. Explanations on the present situation in Europe and America were mentioned. 24 figs., 32 tabs.

7646 (IEE-SR–206) **Analysis of inter-energy competition in the age of complex energies.** Institute of Energy Economics, Tokyo (Japan). 31 Dec 1989. 185p. (In Japanese). Order Number DE89910216. Available from NTIS (US Sales Only), PC A09/MF A01.

This is a survey report of the Japan Energy Economics Research Institute, issued at the end of 1988. Totally 185 pages consisting of 3 sections. Section 1 describes on the image of the energy industry in the time of complex energies (History of changes and competition of energy sources. Formation of the energy market. Energy tax). Section 2 describes the present situation and the prospect of the competition among the energies (Present image of competition — industrial sector, civil household sector, transportation sector and the energy conversion sector. Development of the energy utilization system — cogeneration, regional air conditioning, waste-heat recovery system, individual air conditioning system. Strategic meaning of the expansion of inter-energy competition market). Section 3 describes the arrangement of the fair competitions conditions and the energy policy (Energy policy effect and cost. Energy industrial regulation and its abatement. Competitive energy market and fair competing conditions). 58 figs., 85 tabs.

7647 (STF–11A89036) **The role of the heat pump in the Norwegian energy supply.** Rismark, O.; Stene, J.; Aarseen, A. Selskapet for Industriell og Teknisk Forskning, Trondheim (Norway). Jun 1989. 50p. (In Norwegian). Order Number DE90728264. Available from NTIS (US Sales Only), PC A03/MF A01.

In Norway, the heat pumps should be an important means to meet the Brundtland commission's recommendations to increase the concentration on energy effective and environmentally friendly energy production. The reason for this is, firstly, that the heat pump technology represents the most energy effective way to meet a demand for heating. Secondly, where the heat pumps replace the combustion of oil, the environmentally detrimental emissions (SO_2, CO_2, NO_2) are reduced by 90-100%. Finally, the heat pumps are mainly based on renewable resources. If heat pumps are to be used on a large scale in Norway, the present framework conditions have to be changed. Possible initiatives may be: (1) Environment tax on primary energy (e.g. oil for direct heating). (2) Investment grants to environmentally friendly energy conservation measures, including heat pumps. (3) Advantageous electricity tariffs for heat pumps. 21 refs., 12 figs., 11 tabs. (OH).

2901 Energy Analysis and Modeling

Refer also to citation(s) 7097, 7681, 7709, 7710, 7711, 7813, 7814, 8548

7648 (CANWEC–CE-02828, pp. 17) **Principles for long-term forecasting of fuel-and-energy requirements: Report 1.2.3. .** Potapov, V.I.; Orlov, R.V.; Mastepanov, A.M.; Kislova, N.E.; Woitulewich, Y.; Maron, Y.; Greinert, B. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02828). In *Energy for tomorrow. Division 1: Energy and society: Session 1.2: Planning to meet society's future needs.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper covers principle factors detemining the establishment of levels and structures of energy demand in the USSR. It also considers the role of energy demand forecasting in the whole system of planning the economy and formation of fuel-and-energy balances. In addition, basic forecasting methods and peculiarities of implementing their main stages are discussed.

7649 (CANWEC–CE-02828, pp. 17) **Analysis of the actual energy consumption and long term prevision of the energy intensive industries in Mexico. Mexico-Commission of the European Communities Cooperation Program: Report 1.2.9. .** Bazan, G.; Gonzalez, E. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02828). In *Energy for tomorrow. Division 1: Energy and society: Session 1.2: Planning to meet society's future needs.* Available from Canadian National Committee World Energy Conference, Suite

305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

In 1979, the European Economic Community (EEC) established an international energy cooperation program to provide assistance in energy planning and to transfer methodologies and analytical tools. The Mexico-EEC program, begun in 1985, is currently assisting with energy planning and technical evaluation in the transport, rural development, and industrial sectors. In 1987, Mexico's industrial sector was responsible for 37.7% of the total energy consumed. This paper presents the results of an analysis, using an energy flow model (EFOM), of five high energy intensive industries (cement, steel, sugar, glass, and paper). These industries together accounted for 42.2% of the industrial total energy energy consumption. The conservation potential (cost) by industry can be summarized as follows: the cement industry could reduce consumption by 17% ($100,000,000); the steel industry by 20% ($250,000,000); the sugar industry by 34%; the glass industry by about 10%; and the paper industry by about 15%.

7650 (CANWEC–CE-02828, pp. 26) **Long term energy demand forecasting in France and in Liaoning province (People's Republic of China): Report 1.2.4. .** Siyuan Liao; Garcia, F.; Labrousse, M. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02828). In *Energy for tomorrow. Division 1: Energy and society: Session 1.2: Planning to meet society's future needs.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

An energy demand forecasting exercise that compares energy demand in the province of Liaoning, China with France to the year 2010 is described. Liaoning is similar to France in population and climate but has very different economic and industrial structures. The purpose of the exercise is to evaluate their respective stakes in energy management. A detailed analysis of demand was made by industrial sector, by end-use and by its main determinants (industrial production, stock of dwellings, stocks of vehicles, etc.). An economic scenario characterized by international environment constraints, economic growth, and increasing energy prices was evaluated. Two energy scenarios were evaluated corresponding to contrasting attitudes to energy management. It appears from this analysis that energy management will have an important role in both regions. The result is most significant for Liaoning, which has the more severe economic constraints, because energy savings uinvestment generally costs less per energy unit than energy production. 15 refs., 1 fig., 26 tabs.

7651 (CANWEC–CE-02829, pp. 22) **The role of governments in energy choices: The integration of demand forecastingin energy planning, and the use of ona appropriate approach: Report 1.3.7. .** Pellegrin, J.-P. (Ministere de l'Energie et des Ressources, PQ (Canada)); Corbeil, R. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Quebec has had long experience of energy demand forecasting. Since the beginning of the eighties, this experience has been enriched by the adaptation, to the Quebec situation, of Medee 3 approach, which was designed and developed by the Energy Economics Research Institute (IEJE) of Grenoble. This report provides a review on the integration of energy demand forecasting in the energy planning process of a government and on the use of a specific approach, the Medee approch, for this purpose. The report describes why the Quebec government undertook energy demand forecasting, the nature of such an exercise and the problems that it raises. This report also addresses the method for energy demand forecasting that a government should use taking into account its specific constraints and requirement. In that respect, the advantages of the desaggregated techno-economic approach, like Medee, are emphasized. Two major lessons are drawn from the experience of the government of Quebec: the human and statistical resources required to implement and use such an approach; the impact of the use of the Medee approach on the definition of the energy policy of the government and on its relation with the main other actors of the energy system (federal government, utilities, private energy companies).

7652 (ORNL/FTR–3471) **[Discussion of national teams for CADDET [Center for the Analysis and Dissemination of Demonstrated Energy Technologies]]: Foreign trip report, October 30, 1989–November 3, 1989.** Brown, M.A. Oak Ridge National Lab., TN (USA). 15 Nov 1989. 7p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC05-84OR21400. Order Number DE90003386. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The traveler attended a workshop to discuss the operation of CADDET National Teams. The National Teams are the vital link between the Center and each country's energy end-users. They are responsible for passing information from end-users to CADDET, and vice versa. The workshop provided a forum for member countries to exchange ideas about the operation of their National Teams. Other issues discussed at the workshop were: (1) preferences for energy technologies to be studied in future CADDET analyses and (2) methods to evaluate the success of the CADDET operation.

2902 Economics and Sociology

Refer also to citation(s) 6868, 7637, 7651, 7684, 7716, 7723, 7724, 7725, 7732, 7733, 7734, 7735, 7736, 7737, 7757, 7758, 7762, 7763, 7764, 7862, 7865, 8597, 8811

7653 (CANWEC–CE-02827) **Energy for tomorrow. Division 1: Energy and society: Session 1.1: Social implications of energy supply.** Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. vp (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02827). Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This session outlines the national energy policies taken by or recommended to governments of developed and developing nations. Highlights include energy histories and forecasts of several nations, environmental impacts, special problems of developing and remote regions, and risks accompanying energy production. Separate abstracts have been prepared for 11 papers.

7654 (CANWEC–CE-02827, pp. 18) **Socio-economic impact assessment in support of the energy strategy in developing countries: Report 1.1.3. .** Beredjick, N. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02827). In *Energy for tomorrow. Division 1: Energy and society: Session 1.1: Social implications of energy supply.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Project design to improve the supply of commercial energy, particularly electric power, in developing countries and reduce their dependence on traditional fuels are often difficult to justify by conventional economic analysis even though they may bring considerable socio-economic benefits to the population concerned. Such projects may also adversely affect the locality and environment and the costs of the energy they produce may be beyond the means of the potential consumers. It is important, therefore, that the socio-economic impact on development strategies should be objectively assessed in the planning stages and its direct effect on the merit of a particular proposal determined in quantitative terms, as far as this is feasible. The paper demonstrates the need for socio-economic impact analysis and for quantification of impacts and it explains how this may be achieved. It proposes the impact appraisal should be included as a matter of course when setting up energy development strategies, especially in cases where conventional economic analysis is unlikely to show the full merit of a given development. 1 fig.

7655 (CANWEC–CE-02827, pp. 17) **Progress and prospects for renewable energy sources: A European community view:**

Report 1.1.1. . Palz, W.; Shock, R.A.W. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02827). In *Energy for tomorrow. Division 1: Energy and society: Session 1.1: Social implications of energy supply.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Since 1973, the European Community has adoped a policy to decrease its dependence on oil, virtually all of which is imported, and to diversify its energy supplies. This paper outlines what progress has been made in the latter to date, and what can be expected by the year 2010. By expanding renewable resources such as wind, biomass, solar heat, and photovoltaic power, the European Community will have increased renewable energy comsumption from 3% to between 20 and 25% of gross consumption by the year 2010. The degree of success and applicability of these renewable energy resources is discussed. Due to research efforts, many new energy technologies are now cost competitive, under ideal conditions, with conventional energy sources. Lower oil prices, however, have slowed research somewhat. 2 refs., 6 tabs.

7656 (CANWEC–CE-02827, pp. 19) **Integrated energy systems for rural communities: A modelling approach: Report 1.1.5. .** Basu, S.; Choudhury, J.K. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02827). In *Energy for tomorrow. Division 1: Energy and society: Session 1.1: Social implications of energy supply.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Renewable energy forms a larger share of the total energy consumed in the developing countries that in the developed countries and such energy sources are to be more depended upon in villages remote from the electricity grids. In India one out of six villages will remain, due to topographical constraints, virtually inaccessible by the utilities network. For such villages at least, a planned utilisation of local energy sources becomes an imperative. These sources, Viz. direct solar, wind, mini and micro hydro, biogas, biomass etc. are to be so integrated as to form an energy supply system which should meet the total demand, preserve the high quality of supply and be economically acceptable. The renewable sources suffer from a variability with slow (seasonal) and fast (diurnal) cyclic changes along with nearly unpredictable irregularities. The paper attempts a methodology in the planning process of an autonomous integrated energy system for a rural community with optimal utilisation of the available local sources. A river island in the Sunderbans in costal Westal Bengal has been taken as a test village and the plan of an integrated energy system has been worked out. 6 refs., 4 figs., 2 tabs.

7657 (CANWEC–CE-02828, pp. 24) **An analysis of energy needs and options for Mexico: Report 1.2.2. .** Aburto-Avial J.L. (Comision Federal de Electricidad (Mexico)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02828). In *Energy for tomorrow. Division 1: Energy and society: Session 1.2: Planning to meet society's future needs.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Oil has dominated the energy balance of Mexico for half a century; energy prices, although increasing in the last few years, remain low and energy use is inefficient. A review of alternative energy reserves and resources indicates limited hydroelectric, geothermal, and coal energy resources. Hydrocarbons will predominate for decades. Energy demand can be expected to grow at 4.3%/y for the next 30 years according to the trend scenario, and at 2.5% minimum. Mexico does not have pipeline or power transmission capabilities to optimize regional resource sharing. Local generation and consumption predominates. Between now and the year 2000, only energy conservation and the coal option can have significant impacts on the demand for hydrocarbons. After 2000, the coal and nuclear options should play major roles in Mexico's energy balance. 16 refs., 2 figs., 4 tabs.

7658 (CANWEC–CE-02829, pp. 16) **Energy and society: Bases for energy options: Report 1.3.2. .** Garrido, J.A. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The chief object of the paper is to re-examine the relationship between the technology and ethics within the specific context of the energy options. The paper states that today our energy options are conditioned by two sets of relativley autonomous, although interdependent factors. One is the existence of the total set of resources and the technoloy available for their exploitation and use, and the other is the set of economic and social norms concerning the use of these resources. The author attempts to establish the relationship between these two spheres and the traditional division between means and ends, between technical resources and ethical goals. The paper mainly deals with the ethical aspects of energy exploitation, and emphasizes the responsibility for such an approach within the European Community. Conditions necessary for innovations in energy are described.

7659 (CANWEC–CE-02829, pp. 23) **Training in energy planning for third world countries: Report 1.3.14. .** Duhamel, B. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This paper presents the thesis that the needs of people in many third world countries are no adequately addressed by existing energy programs and that these programs should be designed with more reference to local conditions. This presupposes that equipment be technically adapted to local conditions in ways that do not affect performance. A growth scenario low on energy consumption but compatible with a redistribution of such consumption and a combination of centralized and decentralized sub-systems is considered. The energy transition mode thus laid out makes it possible to define the content for training in energy planning which is adapted to the realities of the country. The author concludes that this training must be presented in such a way - educational framework and learning methods - as not to separate it from local conditions in which the decision makers will have to work. Objectives, priorities and kind of apprenticeship are examined which, based on the assimilation of methods, should also facilitate understanding of local development conditions. 13 refs.

7660 (CANWEC–CE-02829, pp. 11) **Energy policy decision making and public opinion: Report 1.3.12. .** Gerstein, L. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The views expressed in the paper are mainly drawn from the personal experience of the author as the energy-policy spokesman of the Christian-Democratic Parliamentary Group and Chairman of Federal Expert Committee on Energy Issues in Federal Republic of Germany. By the example of nuclear energy, he demonstrates the interaction of short-term fluctuation on the world energy market, energy forecasts, specific events and discussions on energy policy, both within the political parties and in the general public. He concludes that the general public's attitude towards nuclear energy shows two initial phases, euphoria followed by scepticism, ideology, an agitation, and finally later in the 1980s, realism. Up to 1983 a consensus prevailed between the leading political parties in Germany regarding the basic energy-policy objectives of minimizing the

supply risk by providing for a well-balanced use of all available energy sources. The resulting attitude had a positive bearing on the public opinion: more than two thirds of the population were in favour of nuclear energy. Since that time the public has become increasingly fearful of nuclear energy. these fears are ascribed to a decreasing awareness of significance of adequate energy supplies, a series of incidents like Chernobyl, exaggeration of problems in the German media, and a decline of credibility of energy forecasts and expert opinion.

7661 (CANWEC–CE-02829, pp. 21) **Energy and public opinion information: Report 1.3.9. .** Angelini, A.M. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This presentation highlights the role of of public opinion and politics in electric power development. The paper points out that in a very few countries, public opinion and the ruling class were called to express their opinion on the problems of an undeniable technical and very complex nature. Thus, public opinion as well as political parties, have to be informed properly and independently about on the nature of the problems before they are asked to give their opinion. It is concluded that to achieve this goal, the first condition to be met is to appeal to primary sources of information, the objectiveness and independence of which are widely recognised. With respect to the choices relating to primary energy sources to be devoted to power generation, plant siting, and the layout of the major distribution network, public acceptan ce has become a constraint which has eventually led to referendums, especially in connection with the nuclear energy. Thus, acceptance of energy development is an essentially political question.

7662 (CANWEC–CE-02829, pp. 17) **Towards a global approach to energy and information for a more efficient society: Report 1.3.1. .** Bouvet, J. (Agence Francaise pour la Maitrise de l'Energie (France)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The main objective of the paper is to describe the intricate relationship between energy and information. Efficiency in the production of goods and services rely on increasing levels of knowledge and information and on targeting of energy sources to specific applications. The author stresses that at the most simple level, efficiency is the product of direct involvement by economic operators in a process that begins with the production of information and ends with informed decisions on concrete action. At a second stage, the information is actively sought, compiled and processed, and long before the decision-making stage is reached, efforts are made to channel action taken into the most opportune endeavors. Examples from the main sectors of the economy are used to show how information technology has brought, or is bringing increased efficiency by contributing to significant reductions in energy demand. He further states that intelligent use of the intimate relationship that exist between information technology and energy efficiency should guide our efforts to promote economic development and protect the environment.

7663 (CANWEC–CE-02834-3.2, pp. 19) **Energy rationalization in Hungary and the role of the world bank: Report 3.2.5. .** Lengyel, L. (Ministry of Industry (Hungary)); Wiegand, G. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02834). In *Energy for tomorrow. Division 3: Energy and the economy: Session 3.2: Major economic influences on energy.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper presents a national energy program for Hungary and discusses management, financial, and economic barriers to the program. Improvements in energy efficiency will require energy auditing, investments at the individual factory level, implementation of an energy pricing policy that increases prices for most users and the restructuring of the industrial sector in order to curtail production in highly energy-intensive industries. Today in Hungary the World Bank has a special role. Support for energy rationalization efforts is imbedded in the Bank's assistance for the overall structural adjustment of industry. Technical, financial and economic barriers slow the adaptation of energy saving techniques, as do the lack of information about appropriate technical options and absence of expertise in energy management, and capital shortage. These problems are to be overcome or removed by the assistance of the World Bank. 5 figs., 3 tabs.

7664 (CANWEC–CE-02834-3.2, pp. 24) **Interpreting changes in industrial energy intensity: concepts and methods with case studies in France and in Quebec: Report 3.2.1. .** Chateau, B. (Inst. d'Economie et de Politique de l'Energie (France)); Lapillonne, B.; Cote, F. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02834). In *Energy for tomorrow. Division 3: Energy and the economy: Session 3.2: Major economic influences on energy.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

One of the most common approachs to illustrate the role of energy in economic growth consists of tracking the evolution of the energy intensity within the productivc sectors of a country. Energy intensity establishes an economic relation between physical energy consumption and net output which is measured by the gross domestic product (GDP). The use of the Divisia index method to assess the changes in energy intensity due to variations in the industrial GDP structure is described. A comparative analysis showing the evolutionary pattern of industrial energy intensity both in France and in Quebec since the early 70s is used to illustrate the significance of structural changes within the industry upon the energy-growth relationship. A new means to interpret changes in energy intensity of every industrial sector is proposed. Finally, the advantages and disadvantages of this method in evaluation of energy efficiency and diversity policies is reviewed. Further assessments in the scope of energy forecasting are also provided. 30 refs., 6 figs., 2 tabs.

7665 (CANWEC–CE-02836, pp. 10) **Decision factors (learned from experience) to consider for an effective use of district heating (DH) with special emphasis on the combined production of heat and electric power (CHP): Report 4.1.11. .** Ricken, J.H.; Knudsen, J.E. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02836). In *Energy for tomorrow. Division 4: Energy and technology: Session 4.1 Energy research and development and other major energy technology issues.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This paper gives the results fo the first 3 meetings of the Danish National Committee on Energy Development, and outlines their approach to district heating and cogeneration of heat and electric powers. It also previews the contents of their final report.

7666 (EFN–30) **The Energy Research Program - from political vision to useful reality.** Schaefer, J. Energiforskningsnaemnden, Stockholm (Sweden). Jun 1989. 236p. (In Swedish). Order Number DE90728326. Available from NTIS (US Sales Only), PC A11/MF A01.

The study was focused on only one link of the realization process - the interplay between the Cabinet Office and the performers. The main result is that implementation of the new knowledge gained seems to be an almost forgotten subfunction of the political work; it does not play any great role either in the performers' information or in the decision preparation, and it does not seem to be noticed to any higher extent by the evaluation of the work. Anyhow the conclusion is that the program in fact has been implemented. The principal impression is that the control from the Office is weak not

least as a consequence of the goal direction not being combined with follow-up and evaluation. Evaluations are carried out, in fact to a great extent, but information of the outcome has not found its way to the authoroties program proposals. Nor has the information been given the critical and reconsidered role that was intended. It can be established that the strong steering, re-consideration and co-ordination was not realized as intended. The authorities have governed the content and the government the appropriations. The Energy Research Program points out the great importance of the executing organizations and at the same time the difficulties encountered in applying a philosophy that is based on steering, evaluation and feed-back. This philosophy demands that the buyer indicates distinct and operational goals and continuously keeps himself informed about the course of events, within and around the program. The questions turning up are whether the conditions of the political task permit either.

7667 (EMR–EP-81-1E) **New and renewable energy: Canadian experience and capabilities.** Department of Energy, Mines and Resources, Ottawa, ON (Canada). Aug 1981. 38p. (CE–02411). Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

The first half of the paper outlines, for each new and renewable energy source, the resource base which exists in Canada, its current and anticipated future exploitation level, the nature and scope of research and development in the area, the capabilities of Canadian industry in relation to both hardware production and design and operational requirements, and important aspects of expertise available in this country. The new and renewable energy forms of most importance for Canada, and therefore those in which it has particular expertise, are biomass (forest management, combustion, gasification and alcohol fuels production), hydro-electric power (all aspects, including hydraulics as applied to tidal and wave energy), wind (vertical axis generators), solar (passive, some aspects of active thermal and photovoltaics) and oil sands and heavy oils. The second part of the paper discusses the application of new and renewable technologies in developing countries, with particular emphasis on the contributions which could be made by Canada. Some technological aspects of these applications are discussed; in addition there is an exploration of the social, economic and institutional implications of energy policy and planning in developing countries.

7668 (IEE-SR–207) **Analysis of competition among kinds of energy at the era of complexed energy. (Report on overseas study).** Institute of Energy Economics, Tokyo (Japan). 31 Dec 1988. 178p. (In Japanese). Order Number DE89910213. Available from NTIS (US Sales Only), PC A09/MF A01.

Transition feature of competition among kinds of energy in America, England, France were explained, and study on movement by each country was reported. As for the characteristic point for each country, revival of coal energy in America, policy for accepting atomic energy as main source in France, and utilization of cheap petroleum gas from North Sea in England, were explained and transition feature of which were given by figures. Energy industries were classified into electricity, town gas, coal, and petroleum, and competitive situation in each country were explained. Energy policy in each country was explained by taking taxation of each country as primary index. 94 figs., 76 tabs.

7669 (LBL–27859) **Cooperation between the US and the USSR in the peaceful uses of atomic energy.** Seaborg, G.T. Lawrence Berkeley Lab., CA (USA). Oct 1989. 29p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC03-76SF00098. (CONF-8910227–3: 50. anniversary of nuclear fission, Leningrad (USSR), 16-20 Oct 1989). Order Number DE90003992. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The decade of the 1960's saw a marked expansion of cooperation between the United States and the Soviet Union for the peaceful uses of atomic energy. In my opinion, this development constituted one of the most encouraging elements in the international scene. Until 1955 contacts between American and Soviet nuclear scientists were virtually nonexistent, as indeed (after World War II) were US-USSR contacts in other fields except as required in formal intergovernmental relations. Then, in July 1955, the discussions of the Heads of Government meeting in Geneva led to the declaration of a policy with the following aims: to lower the barriers which now impede the interchange of information and ideas between our peoples; to lower the barriers which now impede the opportunities of people to travel anywhere in the world for peaceful, friendly purposes, so that all will have a chance to know each other face to face; and to create conditions which will encourage nations to increase the exchange of peaceful goods throughout the world. 8 figs.

7670 (NEI-NO–72, pp. 20) **The impact of oil on the foreign policies of the superpower - and its ramifications on the oil market.** Bergesen, H.O. (The Fridtjof Nansen Institute, Oslo (Norway)). Norsk Petroleumsforening, Oslo (Norway). 1988. (CONF-8805343–: Bergen conference on oil and economics, Bergen (Norway), 3-4 May 1988). In *Bergen conference on oil and economics: Bergen, May 3-4, 1988.* Order Number DE90728218. Available from NTIS (US Sales Only), PC A07/MF A01.

The world oil market will remain on great importance to both superpowers, but for different reasons. However, neither will be able to establish political control over the market on its own in the foreseeable future. Nevertheless, they are likely to make considerable efforts in order to influence the market and its structure to their advantage. These influence attempts will undoubtedly include political intervention. The superpowers will probably maintain their present petro-political strategies: For the USA the basic inclination will be towards an economic competitive strategy - with political overtones of varying and unpredictable strength. For the USSR, I expect to see a continuation of its commercial strategy vis-a-vis the West, some rhetoric, but little action vis-a-vis OPEC and occasional blackmail of allies. 9 refs.

7671 (VTT-SYMP–102, pp. 35-48) **Social and environmental aspects of energy systems.** Okorokov, V.R. (International Institute for Applied Systems Analysis, Laxenburg (Austria)). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

Total consumption of all forms of energy is very high at present. During a half hour about 250 000 tons of coal will be mined worldwide. During the same half hour over one million barrels of crude oil, or about 150 000 tons, will be extracted worldwide and nearly 100 million m^3 of natural gas will be pumped from wells or separated from crude oil. Also 0.5 million kW electricity will be transmitted from power plants - energy which could light up 5 billion 100 W bulbs during that half hour (Table 2). Valued in per capita terms, these energy flows come annually to nearly 70 GJ, equivalent to about 2.5 tons of hard coal or 1.6 tons of crude oil for every inhabitant of this planet. Far-flung exploration, construction, extraction, conversion, transportation, and transmission efforts have resulted in a huge infrastructure of mines, oil and gas fields, power plants, pipelines, railways, refineries, and high voltage lines- and are in critical dependence on a continuous flow of fuel and electricity. Kinds, modes, and rates of energy consumption are, together with the effects of the natural environment, the most pervasive factors determining the physical amenities of a civilization and as such strongly influence its social organization and intellectual search.

7672 **Connections between economic development energy and electricity consumption: an econometric analysis of statistic datas under the 1970-1985 period.** Beckers, A.; Garnier, N. *Revue de l'Energie (France),* 40(413): 603-620 (Aug-Sep 1989).

While energy intensity decreases the further the country develops the electricity one has another evolution. This paper has as an aim to describe the relevant determinants of energy and electricity consumption under the historical period 1970-1985. These ones, with the aid of an econometric and analytic examination will be able to explain the divergent energy and electricity intensity variations.

2903 Environment, Health, and Safety

Refer also to citation(s) 6764, 7652, 7713, 7746, 7829, 7842, 8381, 8593

7673 (ACFAAFDF–90004319) **Pioneer synthetic fuels facilities: Early approaches to achieving environmental acceptability.** Advisory Committee on Federal Assistance for Alternative Fuel Demonstration Facilities (USA). 24 Feb 1984. 50p. Order Number DE90004319. Available from OSTI; The Honorable Allen I. Olson, Chairman, Advisory Committee on Federal Assistance for Alternative Fuel Demonstration Facilities, Office of the Governor, Capital Bldg., Bismarck, ND 58505.

A report to The Secretary of Energy.

An issue equally important to environmental, industrial, and public acceptability of the prospective synfuels industry has received much less focus. That is the effectiveness of governmental approaches and involvement as they affect synfuels acceptability. Three commercial synthetic fuel facilities are in advanced stages of construction and operational planning. Each achieved contracts for financial assistance from the US Government under different circumstances and principal legislative authorities. Each has also involved a significantly different approach in dealing with environmental protection. These approaches are summarized in a case study format which examines the interdependence of actions required by Federal, state, and local governments in reviewing and permitting each project and in implementing a process geared to achieve environmental acceptability. These are presented following a brief synopsis of current governmental involvement in ensuring environmental acceptability of the emerging synfuels industry.

7674 (AD-A–211296/9/XAB) **Research priorities in environmental risk assessment. Workshop on research needs in environmental toxicology and chemistry held in Breckenridge, Colorado on August 16-21, 1987. Final report, 15 June 1987-30 June 1988.** Dickson, K. North Texas State Univ., Denton, TX (USA). Inst. of Applied Sciences. 30 Jun 1988. 116p. Available from NTIS, PC A06/MF A01.

The environmental issues facing society are the most critical in our nation's history. Difficult decisions must be made about potentially expensive solutions to environmental problems. Environmental risk assessment will provide the information necessary to ensure that best decisions are made. Environmental risk assessment is the most-efficient, technically sound, and cost-effective approach to providing the information required to make these decisions. However, research is urgently needed to enhance the use of environmental risk assessment. Environmental risk assessment integrates knowledge concerning the possible effects of proposed actions that expose plants, animals, and ecosystems to pollutants or stresses in air, water and soil. The formal scientific techniques used in risk assessment take into account the uncertainty associated with knowledge about effect on the environment and estimate the probability of an identified risk being realized in the environment as a result of a contemplated action. Risk assessment provides technical input to risking management, the process of making decisions about the acceptability of risks and the need for risk reduction. The charge given to workshop participants was to identify technical research needs that would best improve the use and understanding of environmental risk assessment.

7675 (CANWEC–CE-02827, pp. 18) **Risks of energy sources: Report 1.1.8. .** Pop-Jordanov, J. (Univ. of Skopje, Skopje (Yugoslavia)); Pop-Jordanova, N. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02827). In *Energy for tomorrow. Division 1: Energy and society: Session 1.1: Social implications of energy supply.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper is devoted to comparative health and environmental risks of different energy sources and their influence to public perception, social acceptability and decision-making. The technical heights of the risks, expressed in the number of fatalities of labor and public per unit energy output, from fossil, nuclear and renewable sources are analysed and compared. The complete energy cycle from mining to waste disposal, as well as the future trends, are taken into account. A comparison of the risks of different energy systems with the anticipated global and national energy shares by source is also presented. Furthermore, detailed studies of the non-technical dimensions of the energy risks are performed. Using a modified attitude-behaviour model, the cognitive structure underlying the positions towards different energy options is investigated. The survey on several groups of Yugoslav experts and students, before and after Chernobyl, has shown significant changes in the total attitude as well as in the contributions and the importance of different attributes to the nuclear power. In addition, the psychological components of the risk are compared with facts concerning malignancy and malformation rates of Yugoslav children before and after Chernobyl accident. Comparative analysis of the height of the risk, comprising the complete energy cycles, yield the biggest values for fossil sources (except natural gas), followed by renewable and nuclear. Consequently, the most prevailing energy sources seem to be the riskiest ones. 12 refs., 4 figs., 2 tabs.

7676 (CANWEC–CE-02827, pp. 16) **Risk assessment and comparative choices: Report 1.1.7. .** Tyror, J.G.; Allen, F.R.; Taig, A.R. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02827). In *Energy for tomorrow. Division 1: Energy and society: Session 1.1: Social implications of energy supply.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This paper defines risk, discusses how it can be quantified, and explains how risk figures are then utilized. Discussion begins with definitions and the history of risk assessment, as it relates to reliability. Utilization of results for risk comparisons and balancing risk with cost are covered. Probabilistic risk assessment methods are now well developed and can be applied to the technologies used by the energy sector. In decision-making, risks should only be compared on a like-by-like basis, which is often impossible. However, risk assessment leads to a better understanding of risk sources, which in turn leads to a more robust, optimized designs and procedures. 10 refs., 3 figs.

7677 (CANWEC–CE-02832) **Energy for tomorrow. Division 2: Energy and the environment: Session 2.3: Environmental concerns: The role of technology.** Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. vp (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02832). Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This session deals with technological constraints and capabilities in dealing with environmental concerns arising out of energy use. Topics covered include the following: capital shortages, high prices of energy, logical constraints, vulnerability to accidents or deliberate disruption, environmental problems, potential inequity and social unrest, likelihood of failures in large-scale technological environmental and social experiments, and the conflict between the requirement for control planning and the political goals and traditions of some societies. Some papers deal with case studies in different countries. Separate abstracts have been prepared for 10 papers from this conference.

7678 (ERCB–AE-89-AA) **Water recycle guidelines and reporting of water use information for in situ oil sands facilities in Alberta.** Energy Resources Conservation Board, Calgary, AB (Canada). May 1989. 3p. (CE–02824). Available from Energy Resources Conservation Board, 640-5th Ave. SW, Calgary, AB, CAN T2P 3G4. Prices: N/C.

Guidelines for water reclamation at Oil Sands Processing Plants in Alberta are outlined. Outlined are: which plants should recycle, when recycling is practical, recycling rates, and phase-in periods. The procedure for reporting to the Energy Resources Conservation Board and for inquiries is given. The main guidelines may be summarized as follows: all in situ operators with freshwater requirements exceeding approximately 500 dam^3/year (500,000 m_3/year) will be required to recycle produced water. All in situ operators with freshwater requirements below 500 dam^3/y will be required to actively investigate and test recycle technology. The target recycle rate assigned to a project will be based on produced water and will be defined as an annual level. These guidelines must be addressed

in regulatory applications that are reviewed by the Energy Resources Conservation Board and Alberta Environment.

7679 (LA-UR–89-3440-Exc.) **Proceedings of the Conference on technology-based confidence building: Energy and environment: Excerpts.** Los Alamos National Lab., NM (USA). 6 Nov 1989. 27p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-36. (CONF-8907103–Exc.: Conference on technology-based confidence building: energy and environment, Santa Fe, NM (USA), 9-14 Jul 1989). Order Number DE90003363. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This document contains excerpts from the proceedings of the conference on "Technology-based Confidence Building: Energy and the Environment." It contains the agenda for the conference and a document on "Global Warming and Energy Use;" a presentation on "from Militarism to Environmentalism: a New Focus of US-Soviet Relations;" a workshop on environmental challenges; a summary address on "Science, Technology, and World Affairs;" an address entitled "Energy: the Coin of International Understanding;" and concluding remarks.

7680 (NBMAE–89-04146) **Guidelines for an environmental impact assessment of a 400 megawatt coal-fired generating station.** Department of Municipal Affairs and Environment, Fredricton, NB (Canada). 28 Nov 1988. 26p. (MICROLOG–89-04146). Available from PC New Brunswick Electric Power Commission, 515 King St., Fredericton, NB, CAN E3B 4X1; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

The purpose of this document is to provide guidelines relating to the substance, scope, and conduct of an environmental impact assessment (EIA) of a 400 MW coal-fired generating station to be added to the New Brunswick Power generating system. The subjects discussed are: the conduct of the EIA and the preparation of the report (rationale of the project, alternatives to the project, description of the environment, prediction of the environmental effects, and consultation of the public), the comparison of three proposed sites (Belledune, Dalhousie Generating Station, and Coleson Cove Generating Station), and the specific problems of CO_2 and SO_2 emissions. 1 ref.

7681 (RFW–87-03724) **Summary of findings on the siting of propane and natural gas transportation fuel facilities.** Webb (R.F.) Corp. Ltd., Ottawa, ON (Canada). Mar 1988. 55p. (MICROLOG–89-03724). Available from PC Ontario. Ministry of Consumer and Commercial Relations, Communications Branch, 555 Yonge St., 9th Floor, Toronto, ON, CAN M7A 2H6; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

A severe accident involving propane occured in November 1986 at a taxi repair facility located at Weston Road in the City of York, Metropolitan Toronto. In response to this, the Government-Industry Commitee on the Sitting of Propane and Natural Gas Transportation Fuel Facilities was stuck to review the relevant safety regulations in Ontario and to provide guidelines for the Ontario municipalities. The terms of reference and the membership of this Committee are listed in the beginning of the report. Propane refuelling and vehicle conversion incidents as well as natural gas refuelling and vehicle conversion incidents are listed and compared to incidents at gasoline service stations; the refuelling of propane cylinders for barbecues is also considered. Risk assessment studies of gaseous automotive fuels are discussed. The regulations in Ontario which are relevant to the siting and setback issues, plus regulations outside Ontario which may provide guidence on these issues are reviewed. Public perception of safety and nuisance issues is discussed. Recommendations are made to improve the safe storage, transfer and use of gaseous fuels and to improve their perception by the public. The report is followed by a glossary. 2 figs., 7 tabs.

7682 (RISO-M–2808) **Emissions from the Danish building stock and emission reduction from retrofit insulation of dwellings.** Skjerk Christensen, P.; Halsnaes, K.; Nielsen, L.H.; Sorensen, H. Risoe National Lab., Roskilde (Denmark). Sep 1989. 110p. (In Danish). Order Number DE90728132. Available from NTIS (US Sales Only), PC A06/MF A01.

A model has been developed to analyse the economic and technical possibilities for reducing emissions of SO2, NOx, CO2, and PAH in the space heating sector in Denmark. The approach is based on well defined building categories including heating and insulation technologies commonly applied in Denmark. A number of alternatives to these categories are set up and difference project calculations are done taking into account energy consumption, emissions to the environment, and economy. In the model outline these basic alternatives are combined, sorted and accumulated according to given criteria to build up a number of overall scenarios covering sections of the space heating sector. The report presents total emissions of SO2, NOx, CO2, and PAH due to space heating in the Danish building stock. Furthermore, specific emissions and total costs using various comfort heating systems are given. Finally, the emission reduction and economic consequences of a number of retrofit insulation possibilities are presented. The model is a planning tool which provides an overview of a number of scenarios with respect to cost and emission reduction potential. (author) 32 tabs., 10 ills., 10 refs.

7683 **Hazardous waste: Where to put it, where will it go. .** Sather, N.F. (Argonne National Lab., Argonne, IL). *Mechanical Engineering (USA),* 110(9): 70-75 (Sep 1988).

The mounting cost of managing hazardous chemical wastes, already in the tens of billions of dollars annually, constitutes a strong incentive to develop better and less costly waste treatment and site remediation technologies. Work at the U.S. Department of Energy laboratories has been directed toward finding technical solutions to hazardous waste problems at DOE sites. Many of the methods under development at these national laboratories will also be of value in other waste disposal and cleanup applications. Several of the more promising of them are described in this article.

2904 Energy Resources

Refer also to citation(s) 6866, 7678, 7716

7684 (CANWEC–CE-02828, pp. 18) **Energy complex of Siberia: Scientific-technological, economic and environmental problems of development: Report 1.2.8. .** Rudenko, J.N.; Saneev, B.G.; Khrilev, L.S.; Nesterov, I.I.; Yershevich, V.V. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02828). In *Energy for tomorrow. Division 1: Energy and society: Session 1.2: Planning to meet society's future needs.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Rapid development of productive capability of Siberia is an important component of the long-term economic strategy of the USSR. At present, Siberia makes a large contribution to the fuel and energy supply of the USSR. It produces more than 15% of the whole volume of electric power, more than 30% of coal, about 60% of gas, and more than 60% of oil and gas condensate. Development targets of the USSR Energy Program indicate that Siberia will remain the main fuel and energy base in the foreseeable future. Unique energy complexes in Siberia will be further developed: including the existing west Siberian oil-gas, Kuznetsk coal and Angara-Yenisei hydropower complexes, Kansk-Achinsk energy, and east Siberian oil-gas complexes. An energy transportation infrastrucutre is planned. The need to use advanced technologies to maximize efficiency and to meet ecological requirements is indicated. 6 figs., 1 tab.

7685 (CANWEC–CE-02834-3.2, pp. 17) **Issues related to energy supply and demand in Japan's economic restructuring: Report 3.2.4. .** Kibune, Hisao (Inst. of Energy Economics (Japan)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02834). In *Energy for tomorrow. Division 3: Energy and the economy: Session 3.2: Major economic influences on energy.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This report presents an analysis of changes in Japan's energy demand patterns in the period from the oil crisis through 1986 (with energy demand turning upward in fiscal 1987 and thereafter), and changes in the economic environment, and their impact on energy demand. The economic environment in this context includes: transition to an economy supported by expansion of domestic demand; development of electronization; and expansion of direct foreign investments. Japan's primary energy demand showed negative growth in the post-energy-crisis period, due primarily to lower energy consumption for industrial use. This was followed by an upward movement in energy demand in recent years. The yen's rapid appreciation against the U.S. dollar and the rising competitiveness of newly industrialized economies have prompted Japan's manufacturing industries to step up efforts toward rationalization of their production systems in Japan, while also shifting production bases to overseas locations. An increase in direct foreign investments is expected to bring about a decrease in domestic production due to replacement of exports and rising imports, thus leading to a slowdown in growth in energy demand of Japan's manufacturing industries. 4 refs., 7 figs., 2 tabs.

7686 (CANWEC–CE-02834-3.2, pp. 22) **The final uses of energy in Italy: 1970-1987: Report 3.2.3.** . D'Ermo, V.; Barsotti, A.; Carta, G.; Cipolletta, I.; Valant, P. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02834). In *Energy for tomorrow. Division 3: Energy and the economy: Session 3.2: Major economic influences on energy.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper presents data and analysis of energy production and consumption in Italy between 1970 and 1988. Data for energy production (and a comparison with industrial growth), and energy consumption by sector over the period is given. Final energy use in industry seems to be marked by lower demand and a sharp fall in high-and-medium temperature thermal uses. There have been important changes in residential and in tertiary sectors where there is still room for reaching a more rational system for low-temperature uses and for improving the efficiency of electrical equipment. The transport sector has been taking on a structure that tends to translate every increase in mobility into a sharp increase in energy requirements. The current phase of low energy prices and the near prospect of creating a Europewide energy market with the possibility of reduction of taxation on many energy products, especially those utilized in the residential, tertiary and transport sector may dampen interest in the rationalization that seems necessary in terms of reducing dependency on foreign sources and curbing the environmental impact involved in the use of energy sources. 13 refs., 7 figs.

7687 (EMR/MR–85-66TR) **Mining Research Laboratories annual report, 1984-85.** Sabourin, C.A. Canada Centre for Mineral and Energy Technology, Ottawa, ON (Canada). Mining Research Labs. May 1985. 98p. (MICROLOG–89-02410). Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $N/C CAN; MF $10 CAN.

One of the main objectives of CANMET's Energy Research program is to develop the technologies required to conserve and to increase the supply of liquid fossil fuels in Canada to bridge the gap that exists between domestic supply and demand (both internal demand and export opportunities). The Energy Research Laboratories (ERL) respond to this R&D objective on matters related to the upgrading of oil sands; heavy oil and synthetic crude production; coal/bitumen coprocessing; and improved oil and gas domestic heating furnaces. Another major objective is to develop the technologies to burn fossil fuels, mainly coal, under environmentally acceptable conditions; ERL responds to this objective through research in the areas of coal combustion and gasification. This report summarizes the activities of ERL during the fiscal year 1984/85. A recent reorganization of the ERL is summarily described. The total expenses of ERL in 1984/85 were 169 persons/year, $6.375 million in salaries, $3.499 million in operating costs, $2.740 million in capital investments, and $10,000 million in contracts. Included in the report are listings of employees, patents, publications, technical committees, and contracts. 2 figs., 2 tabs.

7688 (EUR–9204) **Achievements of the European Community second energy R&D programme.** McMullan, J.T. (Ulster Univ., Coleraine (UK)); Strub, A.S. Commission of the European Communities, Luxembourg (Luxembourg). Directorate-General for Science, Research and Development. c 1984. 46p. Sponsored by Commission of the European Communities. Available from NTIS (US Sales Only), PC A03/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg.

The European Community has been involved in the traditional fields of energy research since the European Coal and Steel Treaty of 1953 and the creation of the European Atomic Energy Community in 1958. Since the oil price shocks of 1973 and 1979, attention has also turned towards renewable energy supplies, energy conservation and secondary energy carriers. One of the Community responses was to launch the two energy R&D programs aimed at precisely these areas. The first program ran from 1975 to 1979, and the second ran from 1979 to 1983. Both programs were of the indirect action type which aim at stimulating and coordinating contract research throughout the Community, and in which the Commission bears up to 50% of the total contract cost. In some areas, the contracts within the programs have represented the bulk of European R&D expenditure. Both of the energy R&D programs are now complete. The first has been assessed by an external Energy Research Evaluation Team (ERET) which made favorable and positive comments about the performance of the program (EUR 6902 EN, 1980 and EUR 7350 EN, 1981). A discussion of that program is to be found in an earlier report (Achievements of the European Community first energy R&D program, EUR 7320 EN). The present document aims to perform a similar analysis of the second program. 45 refs., 18 figs.

7689 (MMS–90003668) **Mineral revenues: The 1988 report on receipts from Federal and Indian leases: Summary data, 1920–1988.** Minerals Management Service, Washington, DC (USA). Royalty Management Program. [1989]. 122p. Sponsored by U.S. Department of the Interior. Available from OSTI; Mineral Management Service, P.O. Box 101159, Anchorage, AK 99510.

The Department of the Interior and the royalty management staff of the Minerals Management Service (MMS) continued efforts to improve accountability for the Nation's mineral revenues in 1988. Significant program changes were initiated or implemented during the year, and approximately $77.7 million in additional royalties, interest, and liquidated damages was collected in Fiscal Year (FY) 1988 through audits, industry refund denials, exception processing, and a comparison of production and royalty reporting. Mineral revenues from royalties, rents, and bonuses on Federal lands and from royalties and rents on Indian lands increased 11.3 percent, from $3.8 billion in 1987 to nearly $4.3 billion in 1988. The increase resulted from a renewed interest in offshore exploration and development by US petroleum firms manifested by increased leasing activity on Outer Continental Shelf (OCS) lands. 36 tabs.

2905 Research, Development, Demonstration, and Commercialization

Refer also to citation(s) 6825, 6826, 7412, 7413, 7445, 7687, 7712, 7722, 7865, 8204, 8811, 8993

7690 (AOSTRA–8808, pp. 5) **AOSTRA [Alberta Oil Sands Technology and Research Authority] technology development for Alberta oil sands and heavy oil.** Yurko, W.J. (Alberta Oil Sands Technology and Research Authority, Calgary, AB (Canada)); Luhning, R.W. Alberta Oil Sands Technology and Research Authority, Edmonton, AB (Canada). 1988. (CONF-880807–: 4. UNITAR/UNDP international conference on heavy crude and tar sands, Edmonton (Canada), 7-12 Aug 1988; CE–02658). In *UNITAR/UNDP, 4th international conference on heavy crude and tar sands, vol. 4.* Available from Alberta Oil Sands Technology and Research Authority, 500 Highfield Pl., 10010-106 St., Edmonton, AB, CAN T5J 3L8. Prices: $150.00 CAN.

Alberta has about 1.7 trillion barrels of oil in place in its tar sands deposits, about 40% of the world's total. About 270,000 barrels of bitumen are produced per day. About 95,000 barrels are produced by thermal in-situ recover methods, the remainder by produced by surface mining. This paper outlines the research program of AOSTRA [Alberta Oil Sands Research Authority] in developing new technology for the recovery and processing of bitumen and heavy oil. AOSTRA is partially funded by the Alberta government and partially by industry through joint projects. Details are provided on a number of AOSTRA/industry joint projects in the Cold Lake, Peace River, and Athabasca fields. The main research thrust in bitumen recovery technology has concentrated on thermal in-situ methods. Steam based methods of thermal production of bitumen from tar sand predominate. Ultimate recovery is about 20%. The major methods being invesigated to improve recovery include the following: the use of additives such as surfactants, foams, CO2 and natural gas with steam, steam drive methods, combustion following cyclic steam cycling, electric heating, and conventional horizontal wells with steam.

7691 (CANWEC–CE-02836) **Energy for tomorrow. Division 4: Energy and technology: Session 4.1: Energy research and development and other major energy technology issues.** Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. vp (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02836). Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This series of papers devotes itself to the history and direction of world energy technology development, chiefly by outlining the energy planning and technology development in the following countries: Australia, Canada, Hungary, Italy, Republic of Korea, and Saudi Arabia. Alternatives to standard fossil fuel technology, such as photovoltaic and fuel cells, solar ponds, coal, methanol, natural gas, photolysis, tar sands, and cogeneration techniques, are stressed. Separate abstracts have been prepared for 11 papers.

7692 (CANWEC–CE-02836, pp. 17) **An overrview of energy research, development and demonstration in Australia: Report 4.1.2. .** Kolm, J.E. (National Energy Research (Australia)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02836). In *Energy for tomorrow. Division 4: Energy and technology: Session 4.1: Energy research and development and other major energy technology issues.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This paper provides details of the performance of energy R&D in Australia by the different sectors and shows a predominance of public sector funding when compared with some other countries. About two fifths of energy R&D is performed by the private sector, with the public sector (primarily the Commonwealth Scientific and Industrial Research Organisation and tertiary institutions) undertaking the remainder. Both sectors are assisted by directed government grants under the National Energy Research, Development and Demonstration (NERD&D) Program which provides about 10% of national energy R&D funding and attracts a similar level of funding from grantees. The key objectives of the NERD&D Program are described and the program strategy to give effect to those objectives is presented in some detail. The program's approach is one of selective concentration of resources on areas where Australian research and, particularly, development capacity can make an economic impact. The paper concludes by assessing the R&D effort and some results in the context of the strategy described for each R&D stream.

7693 (CANWEC–CE-02836, pp. 24) **Italian contribution to innovation in the energy technologies: Report 4.1.3. .** Bozzoni, T.; Comellini, E.; Jorio, M.V.; Vellone, R. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02836). In *Energy for tomorrow. Division 4: Energy and technology: Session 4.1: Energy research and development and other major energy technology issues.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

In Italy, the development of technology innovation in the production and distribution of energy is aimed at supporting the main objectives of the national energy policy: increased protection of the environment, higher efficiency, flexibility of the system and diversification of the energy sources. Some relevant examples of these innovations are discussed in the paper. They are: the use of coal-water mixtures as an alternative to heavy fuel oil, development of a simplified bubbling fluidized bed for use in cogenerative application, and an improved design of the phosphoric acid fuel cell at Milano. In another innovation smart electrical metering systems utilizing the telephone network for data transmission were installed with high and medium voltage users. It was found that the cost of intelligent meters can be justified for large users of electricity on the basis of energy saved. 5 figs.

7694 (CANWEC–CE-02836, pp. 20) **Saudi Arabia R&D effort in the field of solar energy for national future energy needs: Report 4.1.4. .** Hamad, G. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02836). In *Energy for tomorrow. Division 4: Energy and technology: Session 4.1: Energy research and development and other major energy technology issues.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The objectives of this paper are to outline the Saudi solar energy programs and to describe their importance in fulfilling the future total energy needs of the country, to present lessons learned from joint international funded energy research programs and directly funded programs, and to show the impact of such problems and experiences on the future energy R&D national programs. Saudi Arabia has signed two major interntional agreements aimed at developing its solar enegy resources one with the USA (SOLERAS) and one with the Federal Republic of Germany (HYSOLAR). The SOLERAS program focused on four fields of solar energy utilization: cooling applications for urban environments; development of power supplies for remote locations; a solar powered desalinization project; and the development of solar power resources. The main focus of the HYSOLAR was the production of hydrogen gas using solar energy sources. The direct programs are oriented towards the survey of the available renewable energy resources such as solar and wind, testing of new products, and construction of small demostration projects that are characterized by simple technology and low cost. 22 refs., 4 figs.

7695 (CANWEC–CE-02836, pp. 22) **Developing the potential of the Albertra oil sands: Report 4.1.5. .** Yurko, W.J. (Alberta Oil Sands Technology and Research Authority, AB (Canada)); Luhning, R.W. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02836). In *Energy for tomorrow. Division 4: Energy and technology: Session 4.1: Energy research and development and other major energy technology issues.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This paper discusses the activities of the Alberta Oil Sands Technology and Research Authority (AOSTRA). The over-all objectives of the program are to develop economically-viable production methods for each of the major deposits, to maximize recovery efficiencies, and to minimize environmental impact. Two-thirds of the present bitumen production in Alberta is from mined oil sand. The main research objectives in this area are reduction of mining costs and elimination of the large tailings ponds required with the present hot water extraction process. Dredging is being investigated as an alternative mining method. A new direct coking method, the AOSTRA Taciuk process, which requires no water and produces dry tailings, has been developed for separation of bitumen from oil sands. This process also shows great promise for oil shale processing and refinery waste cleanup. Two solvent-based bitumen separation processes are being tested for improved recovery from lower grade sands, and reduced tailings disposal problems. AOSTRA's policies for cost sharing and for joint technology ownership

and licensing have been widely accepted by industry. AOSTRA has worked successfully with 33 oil companies to date. These joint projects are a very effective technology transfer mechanism, and many of the results are being used commercially. 9 refs., 7 figs., 3 tabs.

7696 (CANWEC–CE-02836, pp. 14) **The role of alternative fuels and conservation in Australia's energy future: Report 4.1.6.** . Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02836). In *Energy for tomorrow. Division 4: Energy and technology: Session 4.1: Energy research and development and other major energy technology issues.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper discusses the role of alternative fuels and energy efficiency in Australia's energy future and the importance of energy research, development and demonstration (RD&D) in this context. It begins by discussing Australia's projected liquid fuel supply situation and emphasises the importance of liquid fuels to the Australian transport sector. The paper then notes that Australia has large resources which provide a major potential source of alternative fuels for transport, before going on to describe the Government's approach to their development. Particular attention is given to those alternative transport fuels identified as having potential in Australia in the short or medium term: liquefied petroleum gas, natural gas in vehicles and methanol. Energy efficiency is also discussed, and the need to ensure that the results of research are transferred to the market place is emphasised. The paper concludes by reiterating the importance of RD&D as a means of helping to meet challenges in the energy sector and noting recent Australian Government commitment in this area.

7697 (CANWEC–CE-02836, pp. 14) **Application and field experience with photovoltaic systems for rural electrification: Report 4.1.8.** . Song, J. (Korea Inst. of Energy and Resources (Republic of Korea)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02836). In *Energy for tomorrow. Division 4: Energy and technology: Session 4.1: Energy research and development and other major energy technology issues.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

In the face of the shortage of energy resources and environmental pollution with the continuing economic growth, Korea must develop new energy technologies to solve these problems. As a measure to expedite developing alternative sources of energy, the Korea Institute of Energy and Resources (KIER) has been carrying out projects of the research and development, demonstration and commercialization of photovoltaic systems. Research and development conducted by KIER is described. Detailed descriptions of field experiences with 6 KW grid-connected system and 25 KW standalone systems for rural electrification are included. These systems have been designed, installed, and orperating since 1987. Near and long-term projects are presented in relation to technology development of advanced materials and solar cells, establishment of indigenous technologies for solar cell and module fabrication, and utilization of efficient photovoltaic systems. Current applications and potential markets for photovoltaic systems in Korea are also discussed. The major markets considered are maritime and residential applications for isolated islands and power sources for consumer electronics. 4 figs., 1 tab.

7698 (EC/CPG–89-05085E) **Environment Canada: Development and demonstration of resource and energy conservation technology annual report, 1987/88.** Environment Canada, Ottawa, ON (Canada). Corporate Planning Group. 1989. 26p. (MICROLOG–89-05085). Available from PC Environment Canada, Library Services, Terrasses de la Chaudiere, 10 Wellington St., Ottawa, ON, CAN K1A 0H3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

Development and demonstration of Resource and Energy Conservation Technology (DRECT) is one of the programs established by the Canadian federal government in 1978 as part of its policy to ensure the development of a science and technology base in end-use and efficiency, and production and conversion of conventional and alternative energy sources. The private sector, provinces and municipalities participate in DRECT through cost-shared projects, with DRECT paying up to 50% of the total estimated costs for approved projects to a maximum of $200,000 per year. This annual report provides an overview of projects approved or completed to date including summaries of specific outstanding projects. A project timetable is included, as well as more detailed reports of some projects, including objective, project description and relevance, and a status report. 3 figs.

7699 (EC/CPG–89-05085F) **Environment Canada: Development and demonstration of resource and energy conservation technology annual report, 1987/88.** Environment Canada, Ottawa, ON (Canada). Corporate Planning Group. 1989. 30p. (MICROLOG–89-05085). Available from PC Environment Canada, Library Services, Terrasses de la Chaudiere, 10 Wellington St., Ottawa, ON, CAN K1A 0H3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

Development and demonstration of Resource and Energy Conservation Technology (DRECT) is one of the programs established by the Canadian federal government in 1978 as part of its policy to ensure the development of a science and technology base in end-use and efficiency, and production and conversion of conventional and alternative energy sources. The private sector, provinces and municipalities participate in DRECT through cost-shared projects, with DRECT paying up to 50% of the total estimated costs for approved projects to a maximum of $200,000 per year. This annual report provides an overview of projects approved or completed to date including summaries of specific outstanding projects. A project timetable is included, as well as more detailed reports of some projects, including objective, project description and relevance, and a status report. 3 figs.

7700 (EMR/CRE–CE-02795) **Canadian renewable energy opportunities.** Efford, I.E. Department of Energy, Mines and Resources, Ottawa, ON (Canada). Conservation and Renewable Energy Branch. Feb 1981. 30p. (CONF-8102119–: McGill student conference on energy, Montreal (Canada), 11-14 Feb 1981; CE–02795). Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

The purpose of this presentation was to discuss the long term potential of renewable sources of energy such as biomass, solar, wind, hydraulic, and geothermal. Also discussed were programs, some dating back to the mid-1970s, that have been initiated by the federal government of Canada for the development of these renewable energy alternatives as a means of displacing fossil fuels. 4 figs.

7701 (VTT-SYMP–98, pp. 23-34) **Present status of Soviet heating power economy.** Katshalin, E.A. (Vsesojuzny teplotehnitceskij institut im. Dzerzhenskogo (USSR)). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (In Finnish, Russian). (CONF-8701165–: Seminar on comparison of drying methods of wet coal and peat, Jyvaeskylae (Finland), 6 Jan 1987). In *Comparison of drying methods of wet coal and peat.* Order Number DE90728211. Available from NTIS (US Sales Only), PC A09/MF A01; NTIS (US Sales Only), PC A09/MF A01.

The author describes in his presentation the present status of Soviet power economy and the future prospects of it. He describes the research work done in the USSR in the field of energy technology and presents briefly the construction work being carried on at present. He also gives an overview on the technology that will be used when utilizing low rank coals of the USSR.

7702 **Tighter tolerances at lower costs.** Thompson, D.C. (Lawrence Livermore National Lab., Livermore, CA); Fix, B.L. *Mechanical Engineering (USA),* 110(9): 36-43 (Sep 1988).

The national laboratories, the National Bureau of Standards, and private industry have all played critical roles in developing the standards that have established precision engineering in the United States. In this article, the author discusses some of the areas where technology transfer has taken place between these groups.

2906 Nuclear Energy

Refer also to citation(s) 7571, 7668, 7678, 7687, 7748, 7880, 8993

7703 (GSF-K–74) **Generation, properties and detection of nuclear radiation.** Goettel, K. Gesellschaft fuer Strahlen- und Umweltforschung m.b.H. Muenchen, Neuherberg (Germany, F.R.). Inst. fuer Strahlenschutz. Apr 1989. 39p. (In German). Order Number DE90732347. Available from NTIS (US Sales Only), PC A03/MF A01.

Reprint of the 5th edition 1980.

Generally comprehensible presentation of atomic structure and radioactive decay, radiation properties, units of measurement for activity and dosage, detection and radiation meters. (HP).

7704 (INP–1326/B) **Nuclear power - help or extermination. The splendours and miseries of energetics development.** Hrynkiewicz, A.; Kolenda, Z. Institute of Nuclear Physics, Cracow (Poland). 1986. 19p. (In Polish). Order Number DE90610984. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

This report has been published soon after a Chernobyl accident. The authors try to answer the following questions: why nuclear power is and will continue be an increasingly widely used source of energy and what is the nuclear risk. In the same time they want to call our attention on the dangerous consequences of the more and more intensive development of conventional energetics based on the combustion, in particular, of coal. The energetic situation in Poland they analysed too. (M.F-W).

7705 **The great epic of nuclear energy in France.** Leny, J.C. (Societe Franco-Americaine de Construction Atomiques (Framatome), 92 - Courbevoie (FR)). *Revue de l'Energie (France)*, 40(413). 772-776 (Aug-Sep 1989).

The story of nuclear energy is a world epic, in which France has played a major role. Curiously enough, the Old World and the New World have succeeded each other in nuclear leadership.

2908 Heat Utilization

Refer also to citation(s) 7464

7706 (CANWEC–CE-02829, pp. 21) **Influence of changes in lifestyle on energy consumption in Iceland: Report 1.3.13. .** Vilhjalmsson, J. (AFL Engineering (Iceland)); Ingimarsson, J.; Baldursson, G. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This paper traces the economic growth, economic development, and pattern of energy consumption in Iceland during the last few decades. Much of the energy consumption is in the form of geothermal energy, which is relatively cheap and free of any environmental problems. The Energy Forecast Committee, a joint working group of the principal bodies in the energy field in Iceland, has published energy forecast reports since 1976. The very fast growth rate of energy consumption in recent decades, will not continue and the demand for energy for heating will be much slower in coming years. Similarly, car ownership and the use of electric appliances by households will increase at a lower rate. Air transport to and from Iceland is estimated to increase in the next few years. 13 figs., 2 tabs.

2910 Conservation

Refer also to citation(s) 7678, 7687, 7734

7707 (CANWEC–CE-02829, pp. 21) **Restructuring in the electricity industry in New Zealand: Report 1.3.3. .** Turner, K.S. (Electricity Corp. of New Zealand Ltd. (New Zealand)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper deals with the economic restructuring of the government departments in New Zealand, which has already produced far reaching, and dramatic effects in a very short time. In the field of electricity, the institutional forms and objectives of New Zealand's newly formed Electricity Coporation are discussed. The paper describes the process of corporisation, the managment structure, and its philosophy, approach to negotiation, discounted cash flow valuation, the negotiation outcome and finally process of privatisation, which is under active consideration. It also deals with the risks and trade-offs associated with such radical changes to the industry.

2920 Supply, Demand, and Forecasting

Refer also to citation(s) 6764, 7650, 7687, 7695, 7717, 7732, 7733, 7735, 7736, 7738

7708 (CANWEC–CE-02827, pp. 18) **IEC [International Electrotechnical Commission] standards as vehicle for technology transfer to developing countries: Report 1.1.4. .** Teichmann, H.T. (International Electrotechnical Commission, Geneva (Switzerland)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02827). In *Energy for tomorrow. Division 1: Energy and society: Session 1.1: Social implications of energy supply.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Electric power supply is inadequate in many developing countries. Their power companies have to cope with a number of constraints which are not always properly assessed in industrialized countries. Transfer of technology is not normally successful unless certain aspects are taken into account: need for a socio-economic balance, need for cooperation on the national and regional level, need for equipment design in line with local requirements, obstacles linked to limited financial resources, obstacles linked to limited human resources, dependence on foreign technical assistance, lack of compatibility of equipment from different suppliers and development of renewable enrgy resources. Standards of the IEC (International Electrotechnical Commission) are an important vehicle for technology transfer in the field of electrical energy. The technical work of the IEC is carried out by more than 200 technical committees and sub-committees. Horizontal committees prepare fundamental guidelines, and product committees deal with specific product requirement. The relevant horizontal committees are listed. A section of product committees is introduced. The paper also describes the positive impact of these standards.

7709 (CANWEC–CE-02829, pp. 17) **Energy in India and role of society in its planning: Report 1.3.11. .** Chaubal, K.V. (Bombay Suburban Electric Supply Ldt. (India)); Bhave, A. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Due to rapid progress in exploration, exploitation and use of energy during the last four decades, installed power generation capacity in India increased from 1,360 MW in 1947 to 55,000 MW in 1987, sustaining a growth rate of 10%. The annual growth rate of commercial energy consumption in India varied between 4.7% to 7.2%. A little less than half of the total needs of energy in India are met from non-commercial energy sources mostly in the rural areas. In the two next decades, India will have to substantially step up the commercial energy production. Problems associated with exploration, exploitation and conversion will need to be resolved. Likewise, the perspective plan for the development of non-conventional and renewable energy sources includes generation/saving to the extent 250 million tonnes of coal replacement including generation of 15,000 MW of electricity by the turn of the century. In the field of rural energy, the concept of meeting energy

needs of each village from decentralised integrated utilization of local non-conventional energy sources is gaining acceptance. That may be the ultimate solution to energy problems of rural India if the political leadership can educate, build public opinion and involve the rural population in the process.

7710 (CANWEC–CE-02834-3.2, pp. 23) **Energy as a factor of economic growth: Report 3.2.8. .** Makarov, A.A. (Academy of Sciences of the USSR (USSR)); Beschinsky, A.A.; Vartazarova, L.S.; Avrekh, G.L. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02834). In *Energy for tomorrow. Division 3: Energy and the economy: Session 3.2: Major economic influences on energy.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper presents the role of energy in the economic growth of the USSR. Historical facts and some simple economic models (relating energy to other factors of production) are presented. Data are shown for per capita consumption of goods and electricity, per capita income, and energy use by industries (such as metal producers). A comparison between manufacturing industries in the USA and the USSR is made. It was concluded that diversification of manufactured goods requires more short term energy spending, which will be offset by energy savings once the new goods are used ultimately for energy conservation. Estimates suggest that up to 30% of increases in labour efficiency will be determined by the use of energy. 2 figs., 1 tab.

7711 (CANWEC–CE-02834-3.2, pp. 20) **Energy supply planning for urban areas: Report 3.2.7. .** Corak, D. (Inst. za elektroprivredu, Zagreb (Yugoslavia)); Muzek, Z.; Dajic, N.; Hill, Z. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02834). In *Energy for tomorrow. Division 3. Energy and the economy: Session 3.2: Major economic influences on energy.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper presents a mathematical model and its results for the energy supply of Zagreb, Yugoslavia, so that long term energy supply policy can then be instituted. Analysis of sensitivity of the model to uncertain events is given. The model can be generalized for many cities. Environmental concerns, factors affecting urban energy supply planning, and a breakdown of energy consumption, by sector, in Yugoslavia are included. Natural gas consumption forcasts for the city of Zagreb are included. 5 refs., 2 figs.

7712 (CANWEC–CE-02834-3.2, pp. 23) **Modeling strategic energy policy issues in Bulgaria: Report 3.2.6. .** Tsvetanov, P. (Bulgarian Academy of Sciences (Bulgaria)); Ruicheva, M. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02834). In *Energy for tomorrow. Division 3: Energy and the economy: Session 3.2: Major economic influences on energy.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper describes the set of economic models and the research procedure designed to address the national energy-economy policy, and some results of a study on energy development of Bulgaria until the year 2010. The set of models comprises a combined model for economic development which includes, for more reliable results, a set of methodologically different macroeconomic and branch models, linked to a specialized package for preliminarey information analysis, common information input and expert procedures for interrelation and assessment. The research procedure consists of four major steps: qualitative formation and description fo the scenario tree of the external conditions, social and economic goals, energy demand and supply policies and its transformation, on the basis of the fuzzy set theory application, into quantitative scenarios. This methodological approach is to some extent universal, and could model strategic development for many nations. 11 refs., 6 figs.

7713 (CMRC–8901, pp. 1-20) **Trend of international energy situation and direction of coal technology development.** Tani, Shigeo (Agency of Natural Resources and Energy, Tokyo, Japan). Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

As the international supply-demand trend of energy, the followings are outlined: the international petroleum situation based on the petroleum reserve, political situation of the Middle East countries and movement of OPEC, the development and use of alternate energy such as coal and nuclear, and the coal supply-demand trend in the world and Japan. The direction of coal use technology is reviewed from the viewpoints of supply-demand, international cooperation, profitability and technology, and the policy for coal use technology in Japan is also give. The followings are appended as references: the changes of petroleum recoverable reserve and reserve production ratio in the world, the petroleum proved reserve and production in each country, the petroleum ultimate recoverable reserve in the world, the petroleum supply-demand and the influence of OPEC on it, the outlook of petroleum supply, the present and outlook of supply-demand for each energy, the communique summary of the 11th IEA board of directors, the cooperation between Japan and IEA or DOE for coal use research, the 8th coal policy report of Japan, the budget for coal use promotion in 1987. 18 figs., 9 tabs.

7714 (Juel-Spez–508) **Integrated energy system studies in USSR and FRG. A working report.** Angewandte Systemanalyse. Belyaev, L.S.; Kavelin, I.Ya.; Kaganovich, B.M.; Filippov, S.P.; Bundschuh, V.; Martinsen, D.; Wagner, H.J.; Walbeck, M. Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Programmgruppe Systemforschung und Technologische Entwicklung. Jul 1989. 39p. Order Number DE90729027. Available from NTIS (US Sales Only), PC A03/MF A01.

The Siberian Energy Institute (SEI) in Irkutsk, USSR and the Kernforschungsanlage Juelich GmbH, FRG have been performing four studies for more than five years on the topic of Integrated Energy Systems (IES). The main function of Integrated Energy Systems is to provide environmental purity, acceptable economic efficiency and reliability of energy supply on using low grade fuels. The paper describes the progress of the work in the period 1986-1988. The report describes the status of work at SEI (Siberian Lignite Basin) and KFA (energy model MARNES and Novel Horizontally IES = NHIES), respectively, related to the application of computerized energy models for the long term aspects (technologies and fuels) of the energy supply and consumption. Relevant criteria for considerations and evaluations are ecology, economy and security of supply. But the ecological threats considered are different in both cases. (orig./HP).

7715 (LA-UR–86-2600, pp. 72-76) **Energy supply and demand in Central America.** Trocki, L.K.; Booth, S.R. Los Alamos National Lab., NM (USA). Fal 1986. In *Los Alamos science, Number 14.* Order Number DE87003612. Available from NTIS, PC A06/MF A01.

Central America, like most developing regions, relies heavily on two forms of energy-imported oil and fuel wood. Continued heavy reliance on these fuels could result in more serious economic repercussions in the future. For example, every dollar spent to pay the oil-import bill precludes the import of a dollar's worth of capital goods that could further production. And the strong market for fuel wood, which has already caused rapid price increases for that energy source, could lead to serious deforestation problems. The Central American can reduce the demand for fuel wood and imported oil by further developing their large potential for hydroelectric energy and geothermal energy, as well as alternatives such as solar energy, crop residues, and peat. Conservation and substitution of indigenous resources could ameliorate potential problems.

7716 (VTT-SYMP–98, pp. 9-22) **Energy supply in Finland.** Asplund, D. (Valtion Teknillinen Tutkimuskeskus, Jyvaeskylae (Finland). Kotimaisten Polttoaineiden Lab.). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (In Finnish, Russian). (CONF-8701165–: Seminar on comparison of drying methods of wet coal and peat, Jyvaeskylae (Finland), 6 Jan 1987). In *Comparison of drying methods of wet coal and peat.* Order Number

DE90728211. Available from NTIS (US Sales Only), PC A09/MF A01; NTIS (US Sales Only), PC A09/MF A01.

Large amounts of energy is used in Finland, due to nordic location, which is causing large demand of heating power. The Finnish industry, especially forest products industry, is using large quantities of energy. The fuels used in Finland are mainly imported. Crude oil is mainly imported from USSR, and coal from USSR, Poland, Australia and USA. The portion of oil is decreasing and the portions of coal and natural gas are increasing, as well as the portion of peat. Industry and heating are the main users of energy in Finland, the portion of industry is about 45% and that of heating about 235. The industrial use of energy has stabilized. The same trend, decreasing of oil utilization and increasing of portion of coal, may be seen also in industrial energy consumption. A large quantity of heating power is produced in district heating systems. The increase has been largest in coal utilizing district heating plants. The turbine power of boiler heating plants of the Finnish forest products industry was 1770 MW in total in 1981. The power of the plants in typically under 100 MW, containing multi-fuel boilers. The total turbine power of other industry is 596 MW, the turbine power of communal heating plants is 1224 MW, the turbine power of Imatran Voima Oy 2718 MW and the turbine power of other electricity companies 2787 MW. The largest plants using peat as fuel are located in towns of Tampere, Joensuu, Jyvaeskylae, Kuopio and Oulu. A 150 MW peat fueled condensing power plant is under construction in commune of Haapavesi. Some natural gas fueled power plants are undder construction. Finland is balancing its consumption of electric power via internordic electric power network. Some electric power is also imported from USSR.

7717 From 1960 to the present day: the reorganization of the world energy balance. Perrin, F. (Institut d'Economie et de Politique de l'Energie, 38 - Grenoble (FR)); Ramain, P. *Revue de l'Energie (France)*, 40(413): 583-594 (Aug-Sep 1989).

During the period since the early sixties, the evolution of the world energy system has been influenced, above all, by the 1973 and 1979 oil shocks and by the slowdown in the world economy. It is now over 15 years since the first oil price rise took place - long enough for it to be possible to take a fresh look at the changes in the world energy system which have taken place since. In attempting to get beyond the crisis as it was perceived at the time can we now bring up to date the real meaning of events since the early sixties. Or, to put it another way, did the crisis not provide us with signals which we were unable to discern at the time. And if so, what were these signals and have they all been understood. In the present article we hope to show that the evolution of the world energy system since 1960 has been characterized by the beginnings of a reorganization (far from complete) of access to energy resources.

2930 Policy, Legislation, and Regulation

Refer also to citation(s) 6921, 7706, 7745, 7759, 8811, 9003

7718 (AFLW–89-05163) **Alberta Energy annual report, 1987/88.** Alberta Dept. of Forestry, Lands and Wildlife, Edmonton, AB (Canada). Public Lands Div. 31 Mar 1988. 33p. (MICROLOG–89-05163). Available from PC Alberta Energy and Natural Resources, Information Centre, 9920-108 St., Edmonton, Alta., CAN T5K 2M4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

The Alberta Department of Energy is responsible for managing the province's energy resources. It applies sound management practices to encourage development of these resources and obtain a fair return of revenue to the province. In carrying out its mandate, the department administers several acts governing the development of energy resouces, including the Mines and Minerals Act, Mineral Titles Redemption Act, Freehold Mineral Rights Tax Act, and Petroleum Incentives Program Act. The department was restructured in 1987/88 to reflect the changed energy environment and the priorities of the government. It has the following divisions: Projects and Supply Development, whose responsibilities include the negotiation of major project agreements and the development of policies relating to energy supply development; Policy Analysis and Planning; Mineral Revenues; Mineral Resources; Scientific and Engineering Services and Research; and Legal Services. Finance and administration is shared with the Department of Forestry, Lands and Wildlife. In this report major departmental activities, including activities aimed at promoting technology development as well as developing and implementing programs on the efficient use of energy, are described according to categories including development initiatives, markets and regulatory issues, energy revenues, Alberta Oil Sands Equity, and energy conservation. Financial statements are also included. 13 figs.

7719 (CANWEC–CE-02827, pp. 15) **An Australian perspective on world energy security: Report 1.1.11. .** Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02827). In *Energy for tomorrow. Division 1: Energy and society: Session 1.1: Social implications of energy supply.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper presents the perspective of the Australian Federal Department of Primary Industries and Energy on world energy security. The paper defines energy security as the ready availability of energy on a consistent basis and at acceptable prices such that the well-being of a country's economy is maintained. An important distinction is drawn between energy security and self-sufficiency in energy. Global energy security is examined as a package of several components on the basis that a number of energy policy responses, none of which will singularly guarantee energy security, will collectively serve to alleviate the consequence of any future supply disruptions. The paper concludes by identifying mechanisms which can be utilised during a short-term crisis and stressing that towards 2000 a new generation of problems will impact on energy security. To overcome environmental concerns, a positive policy response of encouraging energy research and development into technology to eliminate or minimise pollution and an increasing emphasis on energy conservation will minimise constraints to energy security. 2 figs.

7720 (CANWEC–CE-02827, pp. 15) **The twenty-first century energy vision: Report 1.1.2. .** Mukai, Junichiro (Agency of Natural Resources and Energy (Japan)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02827). In *Energy for tomorrow. Division 1: Energy and society: Session 1.1: Social implications of energy supply.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The Japanese Ministry of International Trade and Industry (MITI) developed a set of directions for its twenty-first century energy through discussion with Japanese specialists in the energy field. These directions form a set of guide lines for Japanese energy suppliers for development toward the next century. The guidelines were made not only from the viewpoint of energy supply but also from that of energy demand. It is usual in making such a long-term prospect to pile up the estimates of various energy sources in consideration of their potential. As part of the process long-term energy consumptions trends were analyzed. Security and cost are two key concepts in Japan's energy policy. Adaptability to needs is an other important concept. The weight of the household-service sector will increase steadily in Japan's final energy consumption towards the next century. Japan's needs for energy will become diversified and sophisticated. By the turn of the next century, the use of energy will change from meeting the basic needs of life such as lighting, heating and cooking to meeting the sophisticated needs for more comfortable living environments. Japan's energy supply structure is weak. The importance of technology as the key to solving the overall problems is stressed. Technology plays the role of creating energy, promoting its efficient utilization improving energy; and promoting its efficient utilization and it can also make Japan's energy supply and demand structure strong and flexible, and has the potential of solving the basic problem on energy.

7721 (CANWEC–CE-02828, pp. 19) **On the problem of energy supply of a country with insufficient own energy**

resources: Report 1.2.7. . Todoriev, N.H. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02828). In *Energy for tomorrow. Division 1: Energy and society: Session 1.2: Planning to meet society's future needs.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This paper outlines the main strategies of Bulgaria's energy policy. Maximum utilization of indigenous energy resources is required, the main portion of them being low-calorie lignites (5100-6000 kJ/kg). Special technologies have been developed to use lignite through direct combustion to produce electric and heat energy. The hydroelectric potential of the small, mainly mountainous rivers with irregular flow is also used. Accelerated development of nuclear energy is planned to cover increasing energy demand and to decrease the dependence on imports. The rational conservation of energy is regarded as the third energy source of Bulgaria. Environment protection is to be incorporated in the development of the energy sector. Limitations of emissions of gaseous pollutants in newly built refurbished power projects is planned. The national economy's effective use of energy is to be achieved by the restructuring of the economy, the introduction of new technologies, and the setting up of an economic mechanism stimulating the effective and economic use of energy. 4 figs., 1 tab.

7722 (CANWEC–CE-02828, pp. 10) **Prediction on China's energy needs for 2000: Report 1.2.5. .** Tianjie Miao. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02828). In *Energy for tomorrow. Division 1: Energy and society: Session 1.2: Planing to meet society's future needs.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The Chinese government established a goal in 1980 of quadrupling gross national production output by the year 2000. China's State Planning Commission has forecast energy needs in China for the year 2000 on the basis of economic growth, consumption structure, technology, and equipment available. Energy conservation capabilities incorporating national and international experience were evaluated. Energy conservation measures have been strongly emphasized since 1978. From 1978 to 1988 average production output increased 9.4%/y. Average energy consumption increased only about 4.6%/y. An economic model is developed to predict energy requirements by sector. Energy consumption by fuel source is predicted. Coal will remain the main source of energy, providing 70% of needs. It is projected that half the energy required for the quadrupling of the gross national product can be gained from conservation. 1 fig., 3 tabs.

7723 (CANWEC–CE-02829, pp. 25) **Directions of energy research and policy in developing countries: A review of a group of studies: Report 1.3.6. .** Krugmann, H. (IDRC (Canada)); Leppan, E.D.; Rath, A.; Wong, W. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper traces the impact of the oil price rises in the 1970s on developing countries, and efforts by the international community and affected countries to solve these problems through energy research. It uses examples from three review exercises. The first example is a review undertaken by the International Development Research Centre (IDRC) to derive priorities for energy research in developing countries. The second is one of the largest and most systematic reviews of energy problems and energy research relating to developing countries, undertaken by an independent group of energy specialists from developing countries, and jointly supported by IDRC and the United Nations University (UNU). The third is a review of energy problems and the research directed to solve them over the past 15 years in one small developing country, Ghana. Some of the key findings of each of these reviews are reported and the relationships between policy relevant research and its utilization are discussed. The strengths and limitations of the review process are analyzed and the conclusions reached on the energy priorities of developing countries are outlined. 16 refs., 1 fig.

7724 (CANWEC–CE-02829, pp. 25) **The role of the European parliament in the formulation of energy policy and energy planning in the European community: Report 1.3.4. .** Adam, G. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper reviews the evolution of the European Parliament's stance on overall community energy policy, expressed in terms of the European community's energy policy. It finds these objectives are currently very vulnerable. It looks at the energy research, development and demonstration effort in the community underpinning energy policy in those areas which have received particular attention from the Parliament, such as the nuclear fusion programme, alternative and renewable energies and hydrocarbons research. Regional energy policy and planning in the north east of England are highlighted. On the internal energy market, the author's view is that the implementation of the common carrier concept is crucial and that in the final analysis, the consumer should be able to select his supplier in the electricity sector. The dominant position of oil and the complacency among policy makers which currently prevails is also underlined. 13 refs., 3 tabs.

7725 (CANWEC–CE-02829, pp. 20) **The regulated energy economy versus the free energy market: The West German Experience: Report 1.3.5. .** Liesen, K.; Schwarz, H.-O. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02829). In *Energy for tomorrow. Division 1: Energy and society: Session 1.3: The role of society in energy decision making.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Energy policy in the Federal Republic of Germany has for many years been geared towards secure and reasonably-priced energy supplies which are competitive in the international market while remaining in accord with the protection of the environment and the conservation of valuable resources. This paper overviews West German Energy policy in the following areas: reestablishing a consensus on coal and nuclear power policy; achieving a high standard of environmental protection in the European communities; and strengthening the position of the energy industry as efforts are made to create a single European market for energy. The author emphasizes that no fundamental change in the course of energy in West Germany is needed to solve current energy policy issues or to preserve the underlying goals of this policy. However a more pronounced turn towards the basic principles of the market economy seems necessary and whorthwhile, as does the need for a stable and reliable framework for energy, both at a national level and with an eye to the creation of a single market for energy in Europe.

7726 (CANWEC–CE-02834-3.2, pp. 19) **Actual problems of Poland's energy policy: Report 3.2.2. .** Michna, J. (Polish Academy of Sciences (Poland)); Ney, R. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02834). In *Energy for tomorrow. Division 3: Energy and the economy: Session 3.2: Major economic influences on energy.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper presents recommendations to Poland's government on measures to improve energy policy. The focus is on incentives to use energy rationally, the allocation of funds for research, and the allocation of international aid. The experience gained over the last 5 years is described. The need for the state to change its approach to

controlling the economy is reiterated. Lack of details about the Polish economy make modelling difficult, although no one model should be expected to completely describe it. 10 refs., 6 figs.

7727 (CPA–CE-02812, pp. 37-68) **The evolving regulatory regimes.** Baugh, T. (Canada-Newfoundland Offshore Petroleum Board, NF (Canada)); Ewing, L.; Batcup, a.; Cournoyea, N.; Taschereau, M. Canadian Petroleum Association, Calgary, AB (Canada). 1988. (CONF-8805349–: 15. CPA (Canadian Petroleum Association) Frontier Division workshop, Fairmont (Canada), 8-11 May 1988; CE–02812). In *Managing transition on the Canadian petroleum frontiers.* Available from PC Infopall, Pallister Resource Management, Bay 105, 4116 - 64th. Ave., S.E., Calgary, AB, CAN T2C 2B3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $24.00 CAN; MF $10 CAN.

This panel presentation covered the Canada-Newfoundland offshore agreement, the statutes involved, the authority of the Canada-Newfoundland Offshore Petroleum Board, and its functions and areas of responsibility, and the areas of responsibility of the provincial and federal governments. The first presentation discussed British Columbia's position on anticipated offshore development, covering areas of agreement in the Pacific Accord to date, the coordination between provincial and federal governments, and concluding with suggestions for future directions. The second presentation covered the influence of the 1986 Canada-Nova Scotia accord on the new legislative regime, the current status of the legislation implementing the Accord, ideas on how the new Canada-Nova Scotia Board will operate and how the respective governments will relate to the Board, on some specific instances of how the new regime affects each of the exploration, development and production phases of project. The concluding presentation dealt with the Northern Accord, its relationship with native people in the Northwest Territories, and the effect on Northerners. The final presentation gives an outline of the federal government's perspective and future role in the regulation of the frontier areas. 9 figs.

7728 (IT–CE-02787, pp. 10) **Underground injection of liquid wastes in the United States: Historical problems, regulatory requirements and direction of government funded research.** Beard, J.H. (U.S. Environmental Protection Agency, Washington, DC (USA)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

This paper gives the background of the Safe Drinking Water Act and its implementing regulations, which provide the regulatory framework for the U.S. Environmental Protection Agency's (EPA) responsibility for the control of underground injection of fluids. EPA's regulations established criteria and standards for each of five classes of injection wells and minimum requirements for the Underground Injection Control Branch's state programs. Injection below underground sources of drinking water is through two classes of wells: class I wells for hazardous and other industrial and municipal wastes; and class II wells for oil and gas production wastes. The paper presents the major differences and similarities between class I and class II wells; an overview of the regulated community; an inventory of U.S. class I and class II wells; construction practices for new and existing wells; and an overview of R&D efforts in the area of current technology optimization and new technology development, which have the potential to improve underground practices to ensure protection of human health and the environment. 4 tabs., 2 figs.

7729 (NEB-SS–RH-2-88-F) **Reasons for decision [in the matter of an application by] Trans Quebec and Maritimes Pipeline Inc. Application dated 7 July 1988, as amended, for new tolls effective 1 January 1989 and 1 January 1990.** National Energy Board, Ottawa, ON (Canada). Dec 1988. 28p. (CE–02799). Available from National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: N/C.

Trans Quebec (TQM) & Martimes Pipeline Inc. operates a pipeline for the transmission of natural gas from St. Lazare, Quebec to a point just west of Quebec City. TQM applied for new tolls to be effective January 1, 1989 and January 1, 1990, a change in its common equity ratio and an increase in its rate of return on equity ratio, and an increase in its rate of return on equity. Rate of return issues were addressed in an oral hearing and all other issues were addressed by written submission. This report presents the results of the hearing, including the background to the application, the revenue requirements, rate base, depreciation and amortization, the cost of capital, operating costs, and tariff matters. The Board reduced the requested revenue requirements for both years, denied the request to increase the equity for both years. The monthly toll was thereby reduced also. A list of intervenors and appearances is alo included.

7730 (OEB–89-05523) **Ontario Energy Board annual report 1987/88.** Ontario Energy Board, Toronto, ON (Canada). [1988]. 42p. (MICROLOG–89-05523). Available from PC Ontario Energy Board, 14 Carlton St., 9th Floor, Toronto, Ont., CAN M5B 1J2; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

The Ontario Energy Board is the provincial agency responsible for regulating the province's major energy industries, natural gas and electricity. The Board regulates the provincial natural gas industry in a variety of ways including rate setting, approval of franchise agreements and authorizing the installation of transmission lines. The Board also acts as an advisor to the Minister of Energy on matters relating to the natural gas industry as well as Ontario Hydro. The Board makes recommendations with respect to any proposed Hydro rate increases. Several of these responsibilities are described in greater detail in this report. Also included are summaries of the major decisions taken by the Board during the year. These decisions relate to such matters as transport and storage of gas, rate determinations and reviews, pipeline construction and expropriation, drilling permits, and contracts. A glossary of terms and an outline of the public hearing process are also included.

7731 (ORNL/CON–290) **Federal roles to realize national energy-efficiency opportunities in the 1990s.** Hirst, E. Oak Ridge National Lab., TN (USA). Oct 1989. 47p. Sponsored by U.S. DOE Management & Administration. DOE Contract AC05-84OR21400. Order Number DE90004410. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Improving energy efficiency throughout the US economy is a vital component of our nation's energy future, with many benefits. Improving efficiency can: save money consumers, increase economic productivity and international competitiveness, reduce oil and gas prices by reducing the demand for foreign oil, enhance national security by lowering oil imports, reduce the adverse environmental consequences of fuel cycles, especially acid rain and global warming, add diversity and flexibility to the nation's portfolio of energy resources, respond to public interest in, and support of, energy efficiency. The primary purpose of this report is to suggest expanded roles for the US Department of Energy (DOE) in improving energy efficiency during the 1990s (Table S-1). In an ideal world, the normal workings of the market place would yield optimal energy-efficiency purchase and operating decisions. Unfortunately, distortions in fuel prices, limited access to capital, misplaced incentives, lack of information, and difficulty in processing information complicate energy-related decision making. Thus, consumers in all sectors of the economy underinvest in energy-efficient systems. These market barriers, coupled with growing concern about environmental quality, justify a larger federal role. 7 refs., 13 figs., 8 tabs.

7732 (SAND–89-1860) **Primary Standards Laboratory report, first half 1989.** Sandia National Labs., Albuquerque, NM (USA). Nov 1989. 32p. Sponsored by U.S. DOE Management & Administration. DOE Contract AC04-76DP00789. Order Number DE90004358. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The Primary Standards Laboratory (PSL) operates a system-wide primary standards and calibration metrology program for the US Department of Energy, Albuquerque Operations Office (DOE/AL). The PSL mission is to develop and maintain primary standards; to calibrate electrical, physical, and radiation reference standards for member laboratories (DOE/AL integrated contractors); to conduct technical surveys and audits of these laboratories; and to recommend and implement system-wide improvements. This report

summarizes activities of the PSL for the first half of 1989 and provides information pertinent to the operation of the DOE/AL Standards and Calibration Program. Specific areas covered include development projects, calibration and special measurements, surveys and audits, and significant events. Appendixes cover certifications and reports, commercial calibration laboratories, PSL memoranda, National Bureau of Standards (NBS)/National Institute of Standards and Technology (NIST) test numbers, and a DOE standards and calibration memorandum.

7733 **The energy situation and energy policy in Japan.** Kamata, Y. (Agence pour les Ressources Naturelles de l'Energie (MITI), 75 - Paris (FR)). *Revue de l'Energie (France),* 40(413): 692-702 (Aug-Sep 1989).

Because of a lack of indigenous natural resources and a high dependence on imported oil, Japan has a vulnerable energy supply structure compared with other developed countries. The oil market, meanwhile, is widely expected to tighten in the 1990's, despite the glut that has existed over the past several years. Under these circumstances, Japan has found it necessary to pursue a comprehensive energy policy aimed at securing a stable oil supply, promoting the development and introduction of alternative energy, and encouraging energy conservation. These policies need to be continued from a long-term perspective. The Agency of Natural Resources and Energy, since its establishment in 1973 as part of the Ministry of International Trade and Industry, has played a major role in the planning and implementation of Japanese energy policy.

7734 **Fifteen years of energy policy in the EEC (1974-1989): from affirmation to consolidation.** Maniatopoulos, C. *Revue de l'Energie (France),* 40(413): 682-691 (Aug-Sep 1989).

Each energy policy tends to create an environment which enables users to procure the energy which they need under conditions which are as satisfactory as possible from the point of view of quantity, quality and price. To do this, the policy must take into account not only factors specific to energy savings, but also external elements, and even more so since the energy market, during the last 15 years, has gone through a period of instability and fast change. The oil shocks of 1973 and 1979, as well as the countershock of 1986 along with the troubles which followed them, are at that many different steps in the energy crisis. This crisis has pointed out the vulnerability of the Western European economy to energy supply restrictions and to large fluctuations in energy prices. It has emphasized on the one hand the lack of efficiency in the isolated or dispersed national reactions as well as the dangers of a absence of solidarity between the consuming countries. It has shown on the other hand the necessity of an evolution of supply structures toward less dependence on the outside, which supposes a vigorous energy saving effort, the sustained use, under reasonable economic conditions, of native resources plus the development of sources other than oil.

7735 **Energy management: reflection on french experience.** Chateau, B. (Agence Francaise pour la Maitrise de l'Energie, 75 - Paris). *Revue de l'Energie (France),* 40(413): 667-681 (Aug-Sep 1989).

France is often rightly cited as one of the rare countries which has built and conducted, in a coherent, structured and methodical way, a genuine energy management policy. The first act of this policy goes back to 1974, just after the oil shock. Two clear energy policy orientations were then declared by the French government, i.e. develop nuclear energy for electricity production, economize energy. The corresponding ways and means were immediately set up. These included the energy saving law, heat insulation and heating temperature regulations, and the creation of the Energy Saving Agency (in French AEE). From 1974 to 1981, the AEE was the secular arm of the government for implementing its energy saving policy. It designs and implements the various ways and means - incentives, regulations, laws - thanks to which the technical and behavioral changes, leading to energy savings are firmly engaged. The second act of this policy began in 1981 when the Parliament adopted the National Energy Independence Plan which is mainly founded upon energy demand management.

7736 **Energy in China.** Lalere, J. (Ambassade de France, Beijing (CN)). *Revue de l'Energie (France),* 40(413): 713-718 (Aug-Sep 1989).

China is engaged to day in an ambitious program of economic development aiming at a fourfold increase of its GDP by the end of the century. For achieving this goal, while sustained population growth rate will be experienced, the energy policy should be adapted to cope with rapidly rising requirements. Although China enjoys large energy resources, the supply is quite tense and the balance between supply and demand would be achieved only if significant measures are taken in order to enhance production as well as to save energy. China ranks the forefront in the world in term of global energy resources, however due to its large population, the amount available per capita happents to be very low. In fact, the total quantity of energy resources per capita of China is only about half of the average level of the world. Such a situation has led China to define and implement a coherent energy policy which has received the highest level of priority from the official bodies in charge of the problem at the national level.

7737 **New directions in soviet energy policy.** Locatelli, C. (Institut d'economie et de politique de l'energie, 38 - Grenoble (FR)). *Revue de l'Energie (France),* 40(413): 703-712 (Aug-Sep 1989).

The Soviet energy industry, with its extensive approach to energy management, now finds itself facing increasing difficulties in the exploitation of its resources. The issues raised by these internal constraints go beyond the Soviet Union's domestic situation. Energy policy is clearly at the heart of Soviet export strategy, having become an essential means of earning foreign currency. The fragile equilibrium established during the seventies would appear to be threatened. The maintenance of such an equilibrium requires a new approach to the management of the various internal and external constraints involved. In the immediate short-term, energy export requirements (mainly hydrocarbons) will have to be met. This constraint will perhaps be reinforced by Mikhail Gorbatchev's perestroika movements. Does this mean that the Soviet Union will necessarily have to continue a policy of maximising production, at least in the very short-term. And would such a policy be compatible with the modernization of the Soviet economy. Or are there grounds for the suggestion that a real energy demand management policy is already possible and that such a policy could constitute a lasting solution to existing problems. Future choices will be underpinned by questions such as these and Soviet leaders will have to define new directions in both supply and demand. With the help of the glasnot movement, the development of these new orientations is clearly taking place in a new context.

2940 Fossil Fuels

Refer also to citation(s) 6495, 6822, 6824, 6914, 6915, 6916, 6917, 6922, 6923, 6926, 7686, 7688, 7700, 7728, 7729, 7732, 8393

7738 (AE/P–89-04918) **Alberta Petroleum Incentives Program Fund annual report, 1987/88.** Alberta Energy, Edmonton, AB (Canada). Petroleum Div. [1988]. 10p. (MICROLOG–89-04918). Available from PC Alberta Petroleum Incentives Program Fund, Communications Section, 855 - 8th Ave., SW, Calgary, Alta., CAN T2P 3P1; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

The Alberta Petroleum Incentives Program (APIP) was created in November 1981. APIP's objective is to encourage the exploration and development of Alberta's petroleum and natural gas resources. The program also supports work on tertiary oil recovery projects. Under the program, eligible applicants may obtain APIP incentive payments equal to a percentage of their incurred eligible costs and expenses, including exploration and development expenses for oil and gas wells; geological and geophysical expenses, and development drilling and asset costs related to tertiary oil recovery projects. This report of the year's activities includes an accounting of the total of $2,200 million in incentives paid and the financial statements of the APIP Fund. This program is now being wound up and APIP's Calgary office has been closed.

7739 (CANWEC–CE-02834-3.2, pp. 14) **Natural gas in future energy supply of European CMEA [Council for Mutual Economic Assistance]: Report 3.2.9. .** Kashirov, S.S. (USSR Ministry of Gas (USSR)); Makarov, O.K.; Bohal, L. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02834). In *Energy for tomorrow. Division 3: Energy and the economy: Session 3.2: Major economic influences on energy.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper compares the trends in natural gas consumption between the USSR, Council for Mutual Economic Assistance Countries(COMECON), and Western Europe, and examines the past and future role of natural gas in COMECON countries. Trends noted were as follows: natural gas is being exploited by motor vehicles, chemicals based on natural gas extraction are being developed, and underground storage facilities provide a reliable gas supply for import countries. In 1986, the USSR produced 686 billion cubic metres of natural gas, fully covering its domestic needs. Volumes will grow steadily to the year 2000, creating opportunities for a more stable domestic supply and for increased exports.5 refs., 3 tabs.

7740 (COGLA–89-04905) **Canada Oil and Gas Lands Administration annual report, 1988.** Canada Oil and Las Lands Administration, Ottawa, ON (Canada). [1989]. 51p. (MICROLOG–89-04905). Available from PC Energy, Mines and Resources Canada, Communications Branch, 580 Booth St., Ottawa, Ont., CAN K1A 0E4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

The main responsibility of the agency whose activities are outlined in this report is to regulate exploration, development and production of petroleum and natural gas resources on Canadian crown lands. The lands relevant to its jurisdiction are located in the Yukon Territory, the Northwest Territories, Hudson Bay and most of the Canadian coastal zone. In addition, the agency oversees worker safety, resource conservation, and environmental protection as they relate to the aforementioned fields of responsibility. Some of the highlights of 1988 are as follows. The Canadian and Newfoundland governments have signed an agreement in principle with Mobil and its associates for developing the Hibernia offshore field. The Canadian parliament has adopted a law setting into effect the Canada-Nova Scotia accord on offshore hydrocarbon resources. Eight delimitation wells and 10 exploration wells were active during the year, one more than in 1987. The Newfoundland offshore was the most active zone in that respect. Gulf Oil has finished its delimitation drilling in the Amauligak Beaufort discovery. The drilling programs for the Norman Wells expansion projects have terminated; at year end, a total of 310 wells were active, of which 158 were production wells and 152 injection wells. A moratorium has been imposed by the Nova Scotia and Canadian governments on exploration on Georges Bank until the year 2000. 19 figs., 13 tabs.

7741 (Juel–2241) **Fossil fuel conversion in integrated energy systems of the future.** Hiller, H. Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Forschungsgruppe Wirtschaft, Energie, Investitionen. Nov 1988. 70p. (In German). Order Number DE90732478. Available from NTIS (US Sales Only), PC A04/MF A01.

This is a 50-year projection of fossil fuel conversion in integrated energy systems. The main conversion processes are named, and their potential for development is assessed. (orig.).

2950 Hydrogen and Synthetic Fuels

Refer also to citation(s) 7686

7742 (CANWEC–CE-02832, pp. 23) **The coming hydrogen age: Preventing world climatic disruption: Report 2.3.3. .** Scott, D.S. (Univ. of Toronto, Toronto, ON (Canada)); Haefele, W. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02832). In *Energy for tomorrow. Division 2: Energy and the environment: Session 2.3: Environmental concerns: The role of technology.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Economic and social effects of global warming caused by heavy use of fossil fuels are reflewed. The world is evolving towards an ultimate hydrogen age, which will be characterised by the pervasive use of two energy currencies, hydrogen and electricity, with little use of fossil fuels. Although the transition to this age will require about a century to complete, the use of hydrogen as a chemical tether within integrated energy systems has already begun. Concepts and principales for assessing and responding to environmetal impact are presented. These include the role of process changes vs. collectors, the impact of material flows, and the concept of investive vs. consumptive resource use. These principles are subsequently used to develop a better appreciation of how energy sector emissions will contribute to anticipated climatic change, and the nature of the changes expected. The coming hydrogen age is discussed using two themes: underlying principles that will drive the transition to the hydrogen age; and the nature of the age itself. The transition can be seen as occuring in two sequential but overlapping waves: integrated energy systems and neat-H_2 technologies. The former will provide a robust platform for the latter. The transition to integrated energy systems is explained. This transition is developing naturally from the evolution of energy intensive industries today. To gain the significant benefits that integration provides, improved systemic resilience, more effective use of resources, higher energy conversion efficiencies, and major reduction in CO_2 emissions, a more planned development will be necessary. The nature of the business oportunities arising from the conversion to hydrogen fuels are discussed. 11 refs.

2960 Electric Power

Refer also to citation(s) 7110, 7462, 7463, 7609, 7671, 7706, 7729, 7813

7743 (BCH/RP–89-04176) **Twenty-year resource plan for the period 1989-2008.** British Columbia Hydro, Vancouver, BC (Canada). Resource Planning Corporate Affairs. Apr 1989. 137p. (MICROLOG–89-04176). Available from PC B.C. Hydro, 970 Burrard St., Vancouver, BC, CAN V6Z 1Y3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

This resource plan reports the strategies and related actions necessary for B.C. Hydro to meet the needs of its customers for the next 20 years. The report begins with a review of events in 1988 that relate to B.C. Hydro's role in the provincial economy, and presents the decision criteria. The report then addresses the markets for electricity through the demand forecast, domestic marketing programs, and the export market outlook. Potential resources, such as the Power Smart program, improvements to existing facilities, coordination and purchases, buying power from independent power producers, downstream benefits arising from he Columbia River Treaty, and new generation projects, are described. The resource plan deals with transmission and generation options, including hydroelectricity, thermal generation, and the use of alternative energy sources. Appendices cover the more technical details of the planning process and corporate policies and assumptions. 15 figs., 14 tabs.

7744 (CANWEC–CE-02828, pp. 19) **Demand side management, an opportunity to economise on the use of electricity: Report 1.2.1. .** Holmin, N. (Swedish State Power Board (Sweden)); Lundberg, G.; Andersson, M. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02828). In *Energy for tomorrow. Division 1: Energy and society: Session 1.2: Planning to meet society's future needs.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Demand-side management (DSM) programs have been developed in Sweden since the middle and late 70s. Initially, the programs focused on sales increase, i.e. strategic load growth.

They were also aimed at increasing sales in off peaktime (valley filling) and at moving consumption from peaktime to off peaktime (load shifting). In the 90s, the DSM programs will also work to reduce the peak load. A new high voltage tariff with a real time peak day withdrawal option is a part of such a DSM program for peak clipping. Eventually there will be shortness in base load capacity. Since new capacity is very costly to build, conservation can be more economically attractive than capacity growth. The DSM programs will turn to strategic conservation. The UPPDRAG projects, in Vattenburg, is aimed at developing technology to reduce energy consumption and developing a sound conservation pricing, marketing, and public education strategy. It will emphasize the use of demonstration projects for determining the effect of various end use methods based on technical as well as behavioral science in the industrial, residential, and commercial sectors. The project will focus on the commercial and residential sectors where savings of 3 to 5.8 TWh and 1.5 TWh per year are possible.

7745 (CANWEC–CE-02832, pp. 27) **End-use/least-cost investment strategies: Report 2.3.1. .** Lovins, A.B. (Rocky Mountain Inst., Old Snowmass, CO (USA)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02832). In *Energy for tomorrow. Division 2: Energy and the environment: Session 2.3: Environmental concerns: The role of technology.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This paper describes the end-use/least cost approach to evaluating energy alternatives. This method begins by examining what the energy is to be used for and then determines how much energy, from what source will do the task the cheapest way. End-use efficiency is discussed under the following topics: new technologies; financing and delivery methods; regulatory reform; cultural change; efficiency and supply. Supply options are discussed under quality matching, matching in scale, renewable supplies and transitional fossil-fuel technologies. The impacts and environmental benefits of each approach is also discussed. Examples are used to demonstrate that revolutionary changes in efficiency technologies, their financing and delivery techniques, and their regulatory and cultural context can create very large potential savings. Cost-effective efficiency investments can greatly reduce, defer, simplify and cheapen supply investments, and can also improve their technical performance. Proven renewable resources alone, cost-effective in the long-run, can probably supply all the energy needs of every country, if technologies for increasing efficiency are introduced first. Such a transition to a least-cost energy systems could yield striking benefits for global development, equity, environmental quality, and security. Although least-cost investment strategy rests on the neoclassical economic criteria which most decision-makers prefer to use, its serious and systematic applications is still at an early stage of political acceptance. 51 figs., 1 tab.

7746 (ERCB–880953) **TransAlta Utilites Corporation [and] the City of Edmonton. 240-kV transmission line Ellerslie-east Edmonton area.** Energy Resources Conservation Board, Calgary, AB (Canada). [1989]. 6p. (CE–02849). Available from Energy Resources Conservation Board, 640-5th Ave. SW, Calgary, AB, CAN T2P 3G4. Prices: $5.00 CAN.

TransAlta Utilities Corporation (TransAlta) requested Energy Resources Conservation Board approval to construct a double circuit 240 kV transmission line in the Ellerslie-East Edmonton area. Following a public hearing of the application, the Board conditionally decided to approve the construction of the line. However, subsequently, the Board decided tc hold a hearing to review the timing of the need for the proposed 240 kV transmission line and, in particular, whether the timing of the need is such that it would allow the Board to consider an application to be filed by the City for approval to construct and operate a similar 240 kV transmission line. Consequently, a public hearing was held in Edmonton on 8 September 1989 by the Board, at which TransAlta appeared under protest. The Board issued an interim decision, dated 15 September 1989, indicating that it was proceeding to obtain the necessary ministerial approvals for the TransAlta application. This report gives its reasons for that decision. The matters considered to arrive at a decision were: the period of delay if an application by the City was to be considered, the need for the line, the risk of not being able to supply the northeast area load in 1990, the cost of providing an adeqate supply for the northeast area load in 1990 without the line, and the concerns of participants other than the City and TransAlta. The list of the participants at the hearing is given at the end of the report.

7747 (HQ–89-03178) **Hydro Quebec development plan 1989-1991, outlook 1998: The future power generation and transmission grid of Hydro Quebec.** Hydro-Quebec, Montreal, PQ (Canada). 1989. 56p. (MICROLOG–89-03178). Available from PC Hydro-Quebec, Centre de diffusion, 75, boul. Dorchester ouest, 14e etage, Montreal, PQ, CAN H2Z 1A4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

Those two reports supplement the Hydro Quebec Development Plan 1989-1991-Outlook 1998. The first one is entitled equipment plan. The present state of production and transport installations is described. The projects proposed by the corporation, as to building power plants and power transmission lines (mainly 735 kVAC), until the year 2006, are recalled. Finally, the possibilities for the longer-term development of the power grid are presented. Since the scenario of development of the power grid has to be constantly revised according to context and technological innovations, Hydro Quebec considers its development program as flexible. The problems of the safety of the power supply, of the exportation of electrical power and of the development of underwater cables are also addressed. In succession with the said report, the second one, entitled equipment location and territory management, deals with legal problems, environmental policy and consulation with the public. 4 refs., 8 tabs.

7748 (INIS-mf–12033) **Perspectives of electricity supply.** Vereinigung Deutscher Elektrizitaetswerke e.V. (VDEW), Frankfurt am Main (Germany, F.R.). 1988. 174p. (In German). (CONF-8812104–: VDEW symposium: perspectives of electricity supply, Frankfurt am Main (Germany, F.R.), 5-7 Dec 1988). Order Number DE90729204. Available from NTIS (US Sales Only), PC A08/MF A01.

The 7 papers read at the symposium discussed the following subjects: Effects of the CO_2 problems of fossil energy systems on the world climate; status and perspectives of the German electricity industry in terms of competitiveness; The European electricity market and the integrated power supply system; Power supply without nuclear power; Costs and rates for households and other customers; Renewable energy sources and their contribution to energy supply in the Federal Republic of Germany; Electricity utilities as service partners. (UA).

7749 (INIS-mf–12033 vp) **Electricity supply without nuclear power - Is it feasible from the view of national economy?.** Scholz, L. (Ifo-Institut fuer Wirtschaftsforschung e.V., Muenchen (Germany, F.R.). Abt. Energie, Rohstoffe, Technologie). Vereinigung Deutscher Elektrizitaetswerke e.V. (VDEW), Frankfurt am Main (Germany, F.R.). 1988. (In German). (CONF-8812104–: VDEW symposium: perspectives of electricity supply, Frankfurt am Main (Germany, F.R.), 5-7 Dec 1988). In *Perspectives of electricity supply.* Order Number DE90729204. Available from NTIS (US Sales Only), PC A08/MF A01.

In 1987, the Ifo Institute presented an analysis of the economic and ecological consequences of an abandonment of nuclear power generation. In addition, the preliminary assumptions and central findings of ten recent 'nuclear phase-out studies' were reviewed in a synoptic analysis. The article attempts a general analysis from the economic point of view and the reasons for the still controversial discussion. (orig.).

7750 (INIS-mf–12033 vp) **German electricity utilities: Looking out to 1992. Status and perspectives of the competitiveness of the German electricity industry.** Strauss, L. (Ueberlandwerk Unterfranken AG, Wuerzburg (Germany, F.R.)). Vereinigung Deutscher Elektrizitaetswerke e.V. (VDEW), Frankfurt am Main (Germany, F.R.). 1988. (In German). (CONF-8812104–: VDEW symposium: perspectives of electricity supply, Frankfurt am Main

(Germany, F.R.), 5-7 Dec 1988). In *Perspectives of electricity supply.* Order Number DE90729204. Available from NTIS (US Sales Only), PC A08/MF A01; NTIS (US Sales Only), PC A08/MF A01.

After giving a short status report on the situation of the German electricity industry, the author reviews the present electricity rates and the prospects of the German electricity industry for the Nineties and for the free European electricity market. (UA).

7751 (INIS-mf–12033 vp) **The European electricity market - transfrontier competition for individual customers or expansion of the integrated system?.** Bierhoff, R. (Vereinigte Saar-Elektrizitaets-AG, Saarbruecken (Germany, F.R.)). Vereinigung Deutscher Elektrizitaetswerke e.V. (VDEW), Frankfurt am Main (Germany, F.R.). 1988. (In German). (CONF-8812104–: VDEW symposium: perspectives of electricity supply, Frankfurt am Main (Germany, F.R.), 5-7 Dec 1988). In *Perspectives of electricity supply.* Order Number DE90729204. Available from NTIS (US Sales Only), PC A08/MF A01; NTIS (US Sales Only), PC A08/MF A01.

The Single European Act came into force on 1 July 1987; it states that the European internal market should be established by the end of 1992, including a European internal electricity market. In this context, some members of the European Commission at Brussels have demanded that all obstacles to competition on the electricity sector, e.g. the present defined supply regions of individual utilities, should be removed so as to enable utilities to compete for individual customers. This implies nothing less than the abandonment of the established electric power supply structures, both on a national and international scale. The author presents a large number of arguments to show why the electricity utilities are not in favour of this demand. (orig./UA).

7752 (INIS-mf–12033 vp) **Why no uniform electricity rates?. Costs and rates for households and other customers.** Gruenberg, P. (Kreiswerke Geilenkirchen-Heinsberg GmbH, Geilenkirchen (Germany, F.R.)). Vereinigung Deutscher Elektrizitaetswerke e.V. (VDEW), Frankfurt am Main (Germany, F.R.). 1988. (In German). (CONF-8812104–: VDEW symposium: perspectives of electricity supply, Frankfurt am Main (Germany, F.R.), 5-7 Dec 1988). In *Perspectives of electricity supply.* Order Number DE90729204. Available from NTIS (US Sales Only), PC A08/MF A01; NTIS (US Sales Only), PC A08/MF A01.

The present electricity rate structure appears to be coming to an end throughout Europe. This impression was supported by the analyses of the UNIPEDE Committee for Tariff and Economic Problems, which were presented at the 21st congress held at Sorrent on May 30 to June 2, 1988. In West Germany, politicians as well as the electricity industry itself are in favour of a new rate structure. The Federal Regulation on Electricity Rates (BTO Elt) may be amended in the present legislative period. Strategies of other European countries should be analyzed with a view to the applicability of their goals and scenarios to the Federal Republic of Germany. (orig.).

7753 (INIS-mf–12033 vp) **The electricity utilities as service partners.** Bechtold, K. (Elektromark Kommunales Elektrizitaetswerk AG, Hagen (Germany, F.R.)). Vereinigung Deutscher Elektrizitaetswerke e.V. (VDEW), Frankfurt am Main (Germany, F.R.). 1988. (In German). (CONF-8812104–: VDEW symposium: perspectives of electricity supply, Frankfurt am Main (Germany, F.R.), 5-7 Dec 1988). In *Perspectives of electricity supply.* Order Number DE90729204. Available from NTIS (US Sales Only), PC A08/MF A01; NTIS (US Sales Only), PC A08/MF A01.

The author attempts a re-orientation or re-definition of the electricity utilities. He defines in how far the electricity utilities should be viewed as service partners by outlining the spectrum of services offered. (UA).

7754 (LBL–28058) **Least-cost utility planning handbook for public utility commissioners: Volume 2. The demand side: Conceptual and methodological issues.** Krause, F. (Lawrence Berkeley Lab., CA (USA)); Eto, J. National Association of Regulatory Utility Commissioners, Washington, DC (USA); Lawrence Berkeley Lab., CA (USA). Dec 1988. 89p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract FG01-87CE27464;AC03-76SF00098. Order Number DE90003996. Available from NTIS, PC A05/MF A01 - OSTI; GPO Dep.

Currently, seventeen states require least-cost planning in the utility sector. Many other states are establishing similar planning procedures an regulations. These developments represent a trend toward greater regulatory and public participation in resource planning. As a result of this trend, regulators need a better understanding of the technical-methodological aspects of least-cost planning. The experience so far with least-cost planning (LCP) has highlighted many areas where technical-methodological issues need to be resolved if we want to effectively implement least-cost planning policies. These issues can be grouped into three broad areas: (1) quantification, comparison and integration of supply options; (2) quantification, comparison and integration of conservation and load management options; and (3) comparison and integration of demand-side with supply-side options. Complexities and uncertainties on the supply side may, on the whole, be larger than those on the demand side, though both are significant. On the supply side, some of the difficulties arise from economies and diseconomies of scale, lead times, construction cost escalation, unit sizes, reliability, availability, fuel prices and escalation, patterns of electricity output over time, environmental impacts, etc. The problem of environmental and other externalities makes the costing of supply sources especially uncertain. 111 refs., 6 figs., 6 tabs.

7755 (NEB-SS–EH-2-89) **Reason for decision in the matter of an application under the National Energy Board Act of Hydro-Quebec for exports to the New York Power Authority.** National Energy Board, Ottawa, ON (Canada). Jul 1989. 36p. (CE–02905). Available from National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: PRICES UPON REQUEST.

This report sets forth the Board's considerations and reasons for its decision on the continuation of exports of summer diversity electricity to the New York Power Authority to October 31, 1998. The report covers the background to the application, the contract, Hydro Quebec's power surplus and export price, and interventions from New Brunswick, Maritime Electric Co., Ontario Hydro, the Quebec government, and the Grand Council of the Crees. The Board issued the licence for the exports as applies for, subject to various conditions.

7756 (OH/EF–881212) **Load forecasts report no. 881212: System demands.** Ontario Hydro, Toronto, ON (Canada). Economics and Forecast Div. Apr 1989. 108p. (MICROLOG–89-03824). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

Two load forecasts are issued each year: a long-term forecast covering approximately 20 years for system planning purposes; and a short-term covering 5 years produced for revenue planning, rate development and budget purposes. This report contains both the short and long-term forecasts approved December 1988. The short-term forecast is prepared using the results of a customer survey, updated economic forecasts, electricity demand forecast models, the latest analysis of the deviations of recent Ontario electricity demands from last year's predictions, and a forecast of incentive-driven demand management and load displacement generation. The long-term forecast is derived by taking into account the short-term forecast, the long-term economic outlook, econometric model estimates, end-use model estimates, the 1987 load forecast, judgemental factors, and the incentive-driven demand management and load displacement generation. A discussion of the methodology and assumptions, uncertainty in the load forecast, and the performance of the 1988 forecast are also given. A glossary is included. 11 figs., 51 tabs.

7757 (SV-UB–1987-29) **Expert systems for power system dispatch: Pre-study.** Berglund, L. Swedish State Power Board, Vaellingby (Sweden). 9 Jun 1987. 104p. (In Swedish). Order Number DE90728297. Available from NTIS (US Sales Only), PC A06/MF A01.

This pre-study will try to explain the concept of expert system and discuss if expert system technology is of any use for Vattenfall, the Swedish State Power Board, within the field of power system dispatch. Power system dispatch and control including control centers and local control systems comprises a number of functions which

are feasible to realize in expert system technique. Internationally there are a large number of reports on AI-applications within this field, in most cases still prototypes. A project group within Vattenfall has studied the benefits with the new technique. The group has also evaluated functions which seem to be feasible to realize in the new technique. The study includes functions both on station and control centre level. The evaluation of functions with expert system potential has been done against a special evaluation model. The evaluation includes possibilities to realize the functions in expert system technique from several aspects: functional, expert system technological, benefits for the user and demonstration effects. The study ends with a proposal to start some shorter demonstration projects which will give some experience and demonstrate the possibilities with the expert system technique. The study also point out certain functions, with expert system potential, which seem to be suitable for more long term development work.

2980 Consumption and Utilization

Refer also to citation(s) 7648, 7670, 7671, 7715, 7721

7758 (CANWEC–CE-02828, pp. 11) **China's future oil demand and socio-economic development: New deliberations: Report 1.2.12.** . Hua Zepeng. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02828). In *Energy for tomorrow. Division 1: Energy and society: Session 1.2: Planning to meet society's future needs.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

This paper studies the interrelationship of socio-economic development and oil demand and puts forward new deliberations on China's future oil needs and socio-economic development. A historical review of oil consumption in China shows that economic development has no definite bearing on oil consumption for a planned economy. The influences of socio-economic development and government policy on oil consumption are discussed with respect to China's realities. For a developing country like China, social needs, in particular, population growth, upgrading of living standard and change in life style have a great impact on oil consumption. Therefore, effective control of population growth and moderation of over-consumption are necessary. Further analysis of the influences of the change in economic structure, development of twonship enterprises, government intervention and energy saving on oil consumption is given. Energy saving is of critical importance for the economic development of developing countries, especially where resources are scarce and should be given top priority in energy planning the forecast of oil needs in 20-30 years is made. Finally, the trend of other energy sources is briefly described and new strategies of China's future energy development are proposed.

7759 (CANWEC–CE-02828, pp. 18) **Energy and development: The Brazilian experience: Report 1.2.11.** . Holtz, A.C.T.; Goldemberg, J.; Gomes, F.B.M. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02828). In *Energy for tomorrow. Division 1: Energy and society: Session 1.2: Planning to meet society's future needs.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

During the period 1967 to 1973, the Brazilian economy grew at a rate of 11.2%/y. Energy demand grew equally fast. During this period both oil imports and the use of hydroelectric power grew rapidly. In the period from 1974 to 1978 after the oil shock, Brazilian policies designed to reduce dependence on imported oil were ineffective. The government subsidized the price of imported petroleum products and reduced the price of electricity. After the second oil shock in 1979, Brazil made serious efforts to promote domestic energy sources. In subsequent years, oil imports decreased, the use of domestic electric energy increased markedly. Alcohol became the dominant fuel for automobiles. 9 refs., 1 fig., 2 tabs.

7760 (CANWEC–CE-02828, pp. 18) **On development of 2000 year's energy industry in Central China: Report 1.2.6.** . Xiafei Fu. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02828). In *Energy for tomorrow. Division 1: Energy and society: Session 1.2: Planning to meet society's future needs.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

In this paper, energy demand forecasts for the end of this century and distribution features of energy resources in central China are described. Prospective development plans for the energy industry in this region for the 21st century are also discussed. The region's natural resources and social-economics environment has emphasized the need for development of heavy industry and agriculture. Due to this economic development pattern, the year 2000's energy demand will be enormous, and consequently, it will be necessary to import a huge amount of energy from nearby regions, coal from north and northwest China, and hydroelectric energy from southwest China. So it is very important to solve the problem of transportation of energy in different ways. At the same time, the region's energy resources will be developed, particularly the energy resources of the huge Yangtze River. In Hunan and Jiangxi provinces a proper development of nuclear power is also needed because of the shortage of coal deposits and limited transportation capabilities in these two provinces. 7 refs., 2 figs., 5 tabs.

7761 (CANWEC–CE-02828, pp. 17) **Jordan's energy policy: Report 1.2.10.** . Aburas, A. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02828). In *Energy for tomorrow. Division 1: Energy and society: Session 1.2: Planning to meet society's future needs.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Jordan's demand for energy has increased at a rate of 14%/y from 1975 to 1984, while its gross domestic product has increased by only 9%/y. Jordan currently imports more than 98% of its energy needs. It established its Ministry of Energy and Mineral Resources (MEMR) in 1984. MEMR's major policy objectives are as follows: to develop domestic energy sources; to improve on the efficiency of energy use; to diversify the fuels used; to protect the environment; and to adopt an energy pricing policy that will provide an incentive to conserve energy. It is expected that indigenous energy resources may at least contribute to about 22% of all primary energy required for Jordan's economy by the year 2000 if more oil and gas are discovered. Otherwise, the renewable energy resources (wind, solar, small hydro) will contribute to about 3% of the total primary energy consumption. Oil will remain crucial to Jordan's economy and its share in the total energy package will be more than 90% by the year 2000. 4 tabs.

7762 (CANWEC–CE-02834-3.2, pp. 18) **An economic analysis of household energy consumption behavior in Korea: Report 3.2.10.** . Lee Sanggon (Inha Univ. (Korea)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02834). In *Energy for tomorrow. Division 3: Energy and the economy: Session 3.2: Major economic influences on energy.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper analyses household energy consumption trends in Korea using a household production function economic model and comparing its results with empirical data gathered by survey. Data tabulated are gross national product (GNP) and GNP per capita, population and economically active population, number of college graduates and family size, all as a function of time (in years, since 1970). These are correlated with household energy consumption since 1976. Findings are that household electricity consumption per person varies inversely with family income and age of family members, directly with family size and level of education of family members. Better insight and more significant results could be obtained with more accurate data. 4 refs., 1 fig., 9 tabs.

7763 From 1960 to the present day: contrasted energy growth paths. Criqui, P. (Centre National de la Recherche Scientifique, 75 - Paris (FR)). *Revue de l'Energie (France),* 40(413): 595-602 (Aug-Sep 1989).

Analyses of energy intensity levels (energy consumption/GDP) for different world regions in the 1960s and early 1970s, showed up two types of energy development. In market economies, energy intensity seemed to increase progressively as the level of affluence increased - the United States having a higher intensity than Europe or Japan, whose intensities were in turn very much higher than those of the developing countries. Two features stood out in the planned economies: on the one hand their intensities were always greater than those of the market economies for comparable income levels; on the other hand, in countries with low incomes, the intensity was very high during the phase when infrastructures and heavy industries were developing, falling off later in the case of medium-income planned economies as they advanced further in their industrialization. From these observations, it was sometimes hypothesized that there existed one, or rather two, mimetic patterns of energy development and that every country, in the course of its development, adopted one or other of them. More than fifteen years after the first oil shock, it is now possible to compare these hypotheses with the actual course of events in recent years. This should not only make it possible to be more accurate when looking at the situation before the oil shocks, but should also make it easier to appreciate the importance of the shifts brought about by more than a decade of uneven developments in both the world economy and energy prices. The existence of complete sets of homogeneous data for energy consumption as well as for economic indicators now make this task easier.

7764 Economic and energy questions facing developing countries in the early 1990s: A multi-regional case study. Blanchard, O. (Institut d'Economie et de Politique de l'Energie, 75 - Paris (FR)). *Revue de l'Energie (France),* 40(413): 719-731 (Aug-Sep 1989).

Our intention here is to look at the contrasting effects which have been observed during the eighties within three particularly varied regions, and their consequences for the nineties in terms of energy and economic planning. We shall look first at Africa before going on to provide a comparative analysis of the economic and energetic situations of South-East Asia and Latin America. We shall then identify the fundamental questions which these three regions will have to face during the nineties.

2990 Unconventional Sources and Power Generation

Refer also to citation(s) 7654, 7655, 7686, 7696, 7699

7765 (CANWEA–88-06463, pp. 469) **Notes for a speech by the [Quebec] associate deputy energy minister.** D'Amours, M.A. Canadian Wind Energy Association, Ottawa, ON (Canada). 1987. (CONF-8610270–: 2. national conference of the Canadian Wind Energy Association, Quebec (Canada), 26-28 Oct 1986; MICROLOG–88-06463). In *2nd National conference of the Canadian Wind Energy Association (CANWEA).* Available from PC Canadian Wind Energy Association, 44A Clarey Avenue, Ottawa, , CAN K1S 2R7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $25.00 CAN; MF $10 CAN.

A discussion is presented on the overall reaction in Quebec towards the insecurity of petroleum supplies and increasing energy prices. In particular, government policies and programs are examined as they relate to energy conservation and to renewable energy sources. Key elements of provincial energy policy are to favor the development of Quebec's own primary energy source, hydroelectricity; the development of other native energy sources; improving the utilization of energy; and supporting the penetration into the Quebec market of natural gas. The economic effects of energy-related developments are assessed. The increasing importance of renewable energy sources is noted. Some government programs of relevance have included subsidization of home insulation, assistance in converting to non-petroleum energy use, energy analysis programs, information diffusion, and research and development. A special mention is made of progress in wind energy.

7766 (INIS-mf–12033 vp) **Renewable energy sources and their contribution to energy supply in the Federal Republic of Germany.** Voss, A. (Stuttgart Univ. (Germany, F.R.). Inst. fuer Kernenergetik und Energiesysteme). Vereinigung Deutscher Elektrizitaetswerke e.V. (VDEW), Frankfurt am Main (Germany, F.R.). 1988. (In German). (CONF-8812104–: VDEW symposium: perspectives of electricity supply, Frankfurt am Main (Germany, F.R.), 5-7 Dec 1988). In *Perspectives of electricity supply.* Order Number DE90729204. Available from NTIS (US Sales Only), PC A08/MF A01; NTIS (US Sales Only), PC A08/MF A01.

The author discusses a problem that is central from the energy-political and energy-economic point of view, namely whether renewable energy sources, if the present knowledge concerning their development potential and the long-term energy supply problems is extrapolated, can be considered to be a reliable element of an energy supply system of the future, and whether steps to convert the present energy supply structure in this direction are justified at this stage. He therefore attempts a summary outline of the present status and future trends of the available technologies for the utilisation of renewable energy sources. He takes into account the abundance of primary energy on the one hand and the long-term necessity of covering a potentially much higher world energy demand with a lower and climatically acceptable volume of fossil fuel. He arrives at the conclusion that the answer to the introductory question must be negative. (UA).

7767 The place of new and renewable energies in french energy policy. Chartier, P. (Agence Francaise pour la Maitrise de l'Energie, 75 - Paris); Clement, D. *Revue de l'Energie (France),* 40(413): 777-791 (Aug-Sep 1989).

Within the worldwide energy system, NREs hold an important position, i.e. potential for developing countries (photovoltaics,...) increasing the value of local resources (biomass, household wastes,...) contributing to reducing specific consumptions (passive solar),.... They also are at the origin of a genuine industrial activity. With a safe nuclear and a clean coal, the NREs, in the medium term, should only have a limited position in energy diversification (aside from rural electrification in the developing countries). The safety of nuclear and the cleanliness of coal, from the atmospheric CO2 point of view, is a wager over the long term. Work on the NREs is a type of insurance. This is why activity is continued in this area, even in the middle of the oil countershock. This effort improves competitiveness of NRE systems even more when the potential technological gains are high.

30 DIRECT ENERGY CONVERSION

3001 MHD Generators

7768 (ANL/MHD–89/1) **User's manual for MGMHD: A multigrid three-dimensional computer code for the analysis of magnetohydrodynamic generators and diffusers.** Bouillard, J.X.; Krazinski, J.L.; Vanka, S.P.; Berry, G.F. Argonne National Lab., IL (USA). Nov 1989. 124p. Sponsored by U.S. DOE Fossil Energy. DOE Contract W-31109-ENG-38. Order Number DE90004453. Available from NTIS, PC A07/MF A01 - OSTI; GPO Dep.

The Multigrid Magnetohydrodynamic (MGMHD) computer code is an updated and improved version of the single-grid Three-Dimensional Magnetohydrodynamic (TDMHD) code developed at Argonne National Laboratory in 1982 for the analysis of magnetohydrodynamic generators and diffusers. The new code retains the TDMHD formulation of three-dimensional partial differential equations for flow and electrical fields but incorporates an advanced multigrid solution algorithm. The magnetohydrodynamic equation set comprises the mass continuity equation, three momentum equations, the energy equation, two turbulence equations, and Maxwell's electrical equations. Turbulence is represented by a two-equation model in which partial differential equations are solved for the turbulence energy and its dissipation rate. Two unique features are provided in the MGMHD code: (1) a full approximation storage (FAS), block implicit multigrid, finite-difference solution procedure for

the cross-stream hydrodynamic equations, and (2) an FAS multigrid finite-difference solution procedure for the cross-stream electrical potential equations. Detailed descriptions of the equations, solution procedures, options available to the user, and input instructions are presented. Numerical solutions of three sample problems (two Faraday generators and a diagonally connected generator) are discussed. For two of the problems, the multigrid and single-grid codes are compared in terms of computational speed and solution accuracy. 30 refs., 48 figs., 13 tabs.

7769 (DOE/PC/90274–T7) **MHD integrated topping cycle project: Seventh quarterly technical progress report, February 1–April 30, 1989.** TRW Space and Technology Group, Redondo Beach, CA (USA). Applied Technology Div. Oct 1989. 179p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC22-87PC90274. (MHD-ITC–89-285). Order Number DE90004141. Available from NTIS, PC A09/MF A01 - OSTI; GPO Dep.

The ITC Project will advance the state-of-the-art in MHD power systems with the design, construction, and integrated testing of 50 MWt power train components which are prototypical of the equipment that will be used in an early commercial scale MHD utility retrofit. Long duration testing of the integrated power train at the Component Development and Integration Facility (CDIF) in Butte, Montana, will be performed, so that by the early 1990's, an engineering data base on the reliability, availability, maintainability and performance of the system will be available to allow scale up of the prototypical designs to the next development level. This Progress Report covers the period February 1, 1989 to April 30, 1989. A number of test and evaluation activities provided data to support the prototypical design efforts. Phase 1 of the 20 MWt power train testing at Avco was completed, providing a baseline for upcoming coal-fired power train testing in the Mark VI facility. Gas-side corrosion tests of candidate combustor materials and brazing and explosion bonding tests on Glidcop were used to obtain information on prototypical combustor design and fabrication details. Evaluation of CDIF test data on the performance of the 50 MWt power train with iron oxide addition indicated that while specific benefits (such as increased channel life) can be derived from iron oxide addition, it has yet to be demonstrated that iron oxide addition improves power output. 65 figs., 23 tabs.

3002 EHD Generators

Refer also to citation(s) 8261

3005 Fuel Cells

Refer also to citation(s) 7187, 7601

7770 (CANWEC–CE-02836, pp. 16) **Fuel cells: Past trends and future prospects: Report 4.1.12.** . Fueki, K. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02836). In *Energy for tomorrow. Division 4: Energy and technology: Session 4.1: Energy research and development and other major energy technology issues.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper defines and discusses several aspects of fuel cells including benefits and applications, such as cogeneration. Fuel cells are electro chemical devices that convert the chemical energy of fuels directly into electricity. The primary benefits of fuel cells are improved power generation with efficiencies at competitive costs with environmental impacts that are magnitudes less than those of conventional fossil fueled power plants. Potential applications are extensive, including opportunities in electric power generating facilities to cogeneration markets and eventually even the important transportation sector. Various fuels can be used, primarily natural gas but in the future also all fossil fuels from gasified coal to liquid and gaseous hydrocarbons and hydrogen. The development of fuel cell technologies has been expensive and risky, but the overall benefits justify the efforts. Today, introductory phosphoric acid fuel cell power plants are being commercially demonstrated. Molten carbonate and solid oxide fuel cells are well under development with commercialization expected before the turn of the century. Realization of the fuel cell benefits, can be accelerated with increased and improved international cooperation and coordination. 7 figs.

7771 (DOE/MC/25170–2779) **Improved anode catalysts for coal gas-fueled phosphoric acid fuel cells: Progress report, June 3–September 2, 1989.** Kackley, N.; Kosek, J.A. Giner, Inc., Waltham, MA (USA). Sep 1989. 10p. Sponsored by U.S. DOE Fossil Energy. DOE Contract AC21-88MC25170. Order Number DE90004016. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The development, optimization and demonstration of contaminant-tolerant anode catalyst formulations for phosphoric acid fuel cells is the overall objective of this project. The goal is to develop supported catalyst systems that will not only be able to operate on feed gases containing high levels of CO, H_2S, and COS, but will, in fact, encourage the shift reaction to convert the CO to additional H_2 or anodically convert CO to Co_2, boosting the power content of the fuel gas. Of CO conversion is not feasible, a secondary goal is to demonstrate CO- and H_2S-tolerant catalysts so that gas cleanup requirements can be minimized. Upper limits for individual contaminant concentrations and mixtures of contaminant gases that can be tolerated by the advanced anode catalysts will be determined. This quarter, the two catalysts selected for testing were Pt-Ti-Ru and Pt-Ti-ZA, hydrogen/hydrogen cell testing continued. 5 tabs. (CBS)

7772 (STU–87-616) **Methanol/air fuel cell for vehicle applications.** Sylwan, C. (Tekniska Hoegskolan, Stockholm (SE). Inst. foer Kemisk Teknologi); Bjoerk, G.; Kiros, Y.; Komlos, P.; Lindstroem, O. Swedish National Board for Technical Development, Stockholm (Sweden). 10 Jan 1989. 7p. (In Swedish). Project STU-742-87-616. Order Number DE90728276. Available from NTIS (US Sales Only), PC A02/MF A01.

An acid-electrolyte methanol-air fuel cell is under development. New methanol-catalysts produced through micro-emulsion technology are tested together with new aircathodes. Several problems have been identified.

32 ENERGY CONSERVATION, CONSUMPTION, AND UTILIZATION

Refer also to citation(s) 7464, 7646, 8223

3201 Buildings

Refer also to citation(s) 7195, 7197, 7199, 7204, 7205, 7206, 7681, 7761

7773 (ACERR–CE-02762) **Edmonton Energy Conservation Centre: Final report. Phase 1. Retrofit.** Alberta/Canada Energy Resources Research Fund, Edmonton, AB (Canada). 1985. 64p. (CE–02762). Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

The main purpose of the Edmonton Energy Conservation Centre is to demonstrate energy efficient retrofit measures and promote residential energy conservation. The Centre is located in a large, city-owned, two-storey house with excellent public accessibility. The house was in need of repair and could be described as an energy sieve. Funding assistance for the retrofit was provided by federal and provincial governments and the business sector. Alberta Housing funded the design of the retrofit, carried out by SunEarth Designs in co-operation with technical experts and consultants to assist reaching design decisions. The design process involved an assessment of the building, rearrangement of spaces to meet new needs, and analysis and solution of energy use problems. Rather than cash contributions, Edmonton businesses donated items that had been budgeted for, such as a new furnace, building materials, kitchen cabinets, and windows and doors. Among the retrofit work described in this report are interior insulation and air sealing throughout, attic insulation, replacement of the heating system and a major upgrading of plumbing and electrical systems, installation of

an air-to-air heat exchanger, and installation of insulation on the exterior below grade. Budgetary information is provided. 2 refs., 14 figs.

7774 (AIRINS–89-04270) **Air permeance of building materials[and summary report].** Bumbaru, D.; Jutras, R.; Patenaude, A. AIR-INS, Inc., St. Laurent, PQ (Canada). 17 Jun 1988. 229p. (MICROLOG–89-04270). Available from PC Canada Mortgage and Housing Corporation, Annex Bldg., 628 Montreal Rd., Ottawa, ON, CAN K1A 0P7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

The need for improved air tightness of the building envelope is now accepted. Air infiltration and exfiltration through the building envelope has been blamed for the premature failure of many new wall systems. To achieve air tightness of a building envelope, an air barrier system should be designed to perform the unique function of resisting air infiltration and/or air exfiltration. To accomplish this, the system must have the following attributes: continuity, strength, air impermeability and durability. Among the above aforementionned attributes, the air impermeability of building materials used to build the air barrier system is certainly the first characteristic to evaluate in order to set limitations. Tests were conducted on orifice plates and building materials. A total of 126 specimens from 36 building materials were tested at static pressure differentials varying from 25 to 100 pascals. These trials indicated that the test method developed was in close agreement with the test method developed by the Institute for Research in Construction. The method is capable of measuring a wide range of air flow rates with reasonable accuracy. In pressure differentials between 25 and 100 pascals, the air flow regime was shown to be mainly laminar. 105 figs., 78 tabs.

7775 (AIRINS–89-04410) **Air permeance of building materials: Summary report.** Bumbaru, D.; Jutras, R.; Patenaude, A. AIR-INS, Inc., St. Laurent, PQ (Canada). 17 Jun 1988. 19p. (MICROLOG–89-04410). Available from PC Canada Mortgage and Housing Corporation, Annex Bldg., 628 Montreal Rd., Ottawa, ON, CAN K1A 0P7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

This project was undertaken to propose and validate a test method to determine the air permeance of building materials. Tests were conducted on orifice plates and on building materials. A total of 126 specimens from 36 building materials were tested at static pressure differentials varying from 25 to 100 Pascal. The test method developed by the present study has been demonstrated by the validation process to be in close agreement with the test method developed by Institute of Research in Construction. The test method has been shown to be capable of measuring air flow rates of 0.005 L/S-m^2 to 30 L/S-m^2 with reasonable accuracies. The study confirmed that at pressure differentials of 25 to 100 pascals the air flow regime through building materials is mainly laminar.

7776 (BFR-G–17-1988) **Energy answers '87: Questions and answers on energy conservation and management in buildings and the built environment.** Elmroth, A. (Royal Inst. of Tech., Stockholm (SE)); Abel, E.; Adamson, B.; Elmberg, A.; Karlsson, B.G.; Ranaeng, L. Swedish Council for Building Research, Stockholm (Sweden). 1988. 80p. Order Number DE90728334. Available from NTIS (US Sales Only), PC A05/MF A01.

A study of the future energy requirements of the built environment indicates that there is still a considerable technical and economic potential for savings, even in relation to present-day prices of electricity and oil, and of course in relation to a future modest increase in prices. It should be possible virtually to halve the present heating requirements of buildings. Based on our experience of energy conservation in buildings, we feel that the net specific energy requirement can be set as low as 100 kWh/m^2,year of heated area for space heating and domestic hot water production when converting or repairing a building. For new buildings it is feasible to set the net energy demand level considerably lower, at a maximum of 70 kWh/m^2,year. Society must provide property-owners with adequate means of financing their energy conservation measures. The picture also includes a plan for future energy prices, including taxation and any special levies. An important element in energy conservation and management is the feedback of results to those who undertake measures or look after the buildings, systems etc., so that they can see the results of their work. This feedback of results is not restricted only to information in connection with some particular application or occasion, but should be seen as a constant job, not least with the aim of maintaining the whole in good condition and of indicating coming requirements for maintenance. 61 figs., 2 tabs.

7777 (BFR-R–50-1989) **Control of indoor temperature in multiple-unit dwellings by central feed-back.** Hedin, B. (Lund Inst. of Tech. (SE). Dept. of Building Science). Swedish Council for Building Research, Stockholm (Sweden). 1989. 248p. (In Swedish). Order Number DE90728324. Available from NTIS (US Sales Only), PC A11/MF A01.

Central feed-back has been utilized in five larger multiple-unit dwellings with waterborne heating and without radiator thermostat valves. Exhaust air temperature was used as a measure of average indoor temperature of the bulding. In extensive experiments central indoor temperature feed-back was compared with control by feed-back from outdoor temperature solely. The experiments were performed in a way permitting the different control methods to be simultaneously used in buildings of the same kind. The central feed-back performed as intended and the average building temperature was accurately controlled. The evaluation of the different control means was based on gratis heat uitlization. A new method of estimating gratis heat utilization from measured data by regression analysis was developed and tested in the report. The method is a further development of the energy signature. Also was analyzed how the gratis heat utilization depends on building, climate, and control method. This is done theoretically by a simple static model, and by a third order dynamic computerized simulation model. The practical gratis heat utilization in the test buildings has been estimated at c. 90% with central feed-back and at 40% without, which is in accordance with the theoretical analysis. These figures refers to the building as a whole and were calculated with average indoor temperature and gratis heat figures. The control accuracy and the gratis heat utilization will however be considerably lower for the individual apartments. Also this factor is analyzed theoretically from esperimental data.

7778 (BRE-BR–126) **Domestic heat pumps: performance and economics.** Grigg, P.; McCall, M. Building Research Establishment, Watford (UK). 1988. 45p. Available from Available from the British Library Document Supply Centre, Boston Spa, Wetherby, West Yorks. LS23 7BQ. Ref. GPB-10247. Price Pound 20.00.

This report, of particular interest to architects, consultants and engineers, describes the performance of electrically driven air to water heat pumps in domestic systems. It is based on the results of full and part load assessment at BRE and experience of their operation at a number of trial installations. It assesses the economics of heat pump purchase and operation in relation to house heating load and seasonal performance and discusses alternative sources of heat, different types of heat pumps and different heat distribution networks. (author).

7779 (CONF-891202–7) **Measured R-values for two horizontal reflective cavities in series.** Petrie, T.W. (Oak Ridge National Lab., TN (USA)); Courville, G.E.; Childs, P.W.; Shipp, P.H. Oak Ridge National Lab., TN (USA). [1989]. 16p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC05-84OR21400. From 4. thermal performance of the exterior envelopes of buildings; Orlando, FL (USA); 4-7 Dec 1989. Order Number DE90003719. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The Large Scale Climate Simulator at the DOE-sponsored Roof Research Center has been used to provide data for steady-state temperatures and heat fluxes in two horizontal reflective cavities in series. The cavities have nominal effective emittances of 0.015 and 0.03 and are relatively narrow. The resulting R-values cover a range of mean air temperatures from −5 F to 135 F and temperature differences from 12 F° to 26 F°. The cavities studied had exposed wood sides. The R-values for heat down-flow fall significantly below those for the same nominal emittances in the ASHRAE Handbook of Fundamentals. Values for heat upflow are slightly lower than the ASHRAE data. Analysis of a graybody radiation network for this situation shows that the lower R-values are the effect

of non-reflecting sides. It also confirms that the sides should be covered with foil. 5 refs., 7 figs., 2 tabs.

7780 (CONF-891202–8) **A guide for estimating potential energy savings from increased solar reflectance of a low-sloped roof.** MacDonald, J.M.; Courville, G.E.; Griggs, E.I.; Sharp, T.R. Oak Ridge National Lab., TN (USA). [1989]. 14p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC05-84OR21400. From 4. thermal performance of the exterior envelopes of buildings; Orlando, FL (USA); 4-7 Dec 1989. Order Number DE90003720. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A guidebook was developed that can be used to evaluate the net energy savings and resultant cost savings associated with changing the solar reflectance of low-sloped roofs. This paper presents an overview of the guide and excerpts to illustrate its use. The guide provides data and calculation procedures for estimating energy and cost savings. In most instances, the cooling cost savings associated with a change to a white roof surface (one with higher solar reflectance) exceed the heating cost penalty. If the difference between reduced cooling costs and increased heating costs is significant, it can affect the choice of membrane for a new roof or a re-roofed building. The guide helps the user estimate this energy cost difference and also describes how various factors influenced potential energy savings and actual roof surface temperatures for different solar reflectances. 8 refs., 4 figs.

7781 (CONF-8908177–2) **Development of a residential size electricity producing condensing furnace.** Wicks, F.; Dykstra, E.; Arnold, M.; DeBeradinis, D.; Leavitt, N. Union Coll., Schenectady, NY (USA). [1989]. 6p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract FG01-88CE15390. From 24. intersociety energy conversion engineering conference; Washington, DC (USA); 6-11 Aug 1989. Order Number DE90003749. Available from NTIS, PC A02/MF A01 - OSTI.

The subject system combines the fuel saving technique of cogeneration and the fuel saving technique of a condensing furnace in a system that is fundamentally simpler than existing furnaces and has the potential of replacing virtually every existing furnace in a highly fuel efficient and cost effective manner. The realization of these benefits will require solution to difficult, but solvable, problems. The system has been recommended by the National Bureau of Standards and awarded a grant by the United States Department of Energy. It has been recognized with an ASME Energy Innovation Award and featured in major magazine and newspaper articles. Patents have been allowed or are pending in most major countries. This paper will describe the development status in terms of successes and remaining problems to solve. 9 figs.

7782 (DTH-LV-MEDD–198) **Energy saving ceilings over skating rinks: Reflecting screen that will restrain condensation.** Bolet, B.; Rasmussen, N.H.; Korsgaard, V. Danmarks Tekniske Hoejskole, Lyngby (Denmark). Lab. for Varmeisolering. Dec 1988. 66p. (In Danish). Order Number DE90728156. Available from NTIS (US Sales Only), PC A04/MF A01.

The aim of this project has been to reduce the energy consumption by putting up an extra ceiling with low emission, a socalled reflecting screen, in already existing ice rinks. The purpose of the reflecting screen is to reduce the energy consumption for cooling of the ice and a possible heating of the room. Problems concerning condensation on the ceiling and consequent dripping and damaging of the roof will also be reduced. The effect of the reflecting screen has been both studied by model tests and theoretic calculations and by computer calculations. The reflecting screen has then been tested in ice rinks both in roedovre and in Hoersholm in 1982 and 1983 respectively, in both cases the reflecting screen was made of bright aluminium screens mounted under the ceiling. Measurements have been made of the energy consumption for calculations of the electricity and heating economy. The results have been, that the consumption of electricity for cooling of the ice has been reduced by about 13-14 % in the ice rink in Roedovre and by 9-27 % in Hoersholm after mounting of the reflecting screen, and the heat consumption in Hoersholm has been reduced by 27-30 %, which means an annual saving of about 32.000 kr. in Roedovre and 140.000 in Hoersholm. The registration of condensation in the ice rink in Roedovre further proves that it is possible to improve the condensation problems in non-heated ice rinks considerably. To avoid all condensation the reflecting screen must be slightly heated. (AB) 10 refs.

7783 (DTH-LV-MEDD–208) **Silica aerogel windows in Danish residential buildings: Assessment of possibilities for energy conservation.** Bruun Joergensen, O. Danmarks Tekniske Hoejskole, Lyngby (Denmark). Lab. for Varmeisolering. Jul 1989. 67p. (In Danish). Contract EM-1213-701-01-02;Contract EM-1213/87-1. Order Number DE90728124. Available from NTIS (US Sales Only), PC A04/MF A01.

EFP-87.

The main purpose of this report has been to describe the potential energy saving by replacing all windows in the Danish building stock by highly insulated windows with monolithic silica aerogel, the so-called Airglass-windows. A description of the buildings is given by describing different types of buildings concerning type, age and number. A description is then given of the design of the applied windows and their optical and thermal insulating abilities. These characteristics are based on both measured and theoretical values. The transmittance of the Airglass-windows has been set to only 13% less than the transmittance of ordinary double-pane windows. The heat loss coefficient of the windows typically varies between 0.6 and 0.8 W/m2K, when due consideration has been given to the cold bridges at the edge of the windows. According to the building stock description the possible energy saving is calculated, and an evaluation of possible discomfort, due to the replacement of the windows has been made. The examination shows that by changing all windows a reduction of the energy consumption for room heating of 18% can be optained. Typically savings of 220 kWh per m2 changed window, no matter the age and condition of the dwelling, can be expected. Analyses concerning the thermal comfort shows that there will be no aggravation of the thermal indoor climate concerning surplus heating. An estimate of the influence of different parameters on the energy savings is made by extensive computer simulations. Finally an economic evaluation is carried out, in which the maximum price of the Airglass-windows has been calculated, so that a replacement, as described here, becomes profitable. (AB).

7784 (ETDE-mf–0732479) **Systems for exploitation of solar, wind and biogas energy in the People's Republic of China. Phase III. Partial project planning of settlement and buildings. Final report.** Schreck, H.; Hillmann, G.; Nagel, J. Institut fuer Bau-, Umwelt- und Solarforschung G.m.b.H., Berlin (Germany, F.R.); Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). Dec 1987. 21p. (In German). Contract BMFT 03E 4444 C. Order Number DE90732479. Available from NTIS (US Sales Only), PC A03/MF A01.

Various passive solar buildings were planned as dwellings and communal buildings in a village in China. The aim of the plan was to reduce the energy demand by planning and design so that the required heat energy demand could be largely covered by simple passive methods of using solar energy. The energy demand could be reduced by steady state and temporary thermal insulation of the outer walls of buildings in a direct and indirect way (conical walls, greenhouse effect). During test and measurement phases lasting several years, the ability of the integrated passive solar energy obtention components to function was confirmed and the considerable energy gain due to solar heat and an acceptable room climate were proved. Data are given on building design (roofs, external walls, windows, extensions, passive and active solar components). (HWJ) With 6 figs.

7785 (ETDE-mf–9785672) **Systematization of the environmental conditioning project in buildings with a view to optimizing the architectural projects with regard to environmental control and energy saving.** Klainsek, J.C. Universidad Politecnica de Madrid (Spain). Escuela Tecnica Superior de Arquitectura. 1988. 380p. (In Spanish). Order Number DE89785672. Available from NTIS (US Sales Only), PC A17.

Due to its significance, energy analysis should be taken into account in both developing and optimization of hygrothermic conditioning system and new building designs. It is also necessary to determine the actual costs of energy saving and conservation modifications for existing buildings. This analysis involves a large number of repetitive calculations, so a computer application has become a necessity and a computer program has been developed to

simulate energy needs for a real life office and their functions in one climate region. This program predicts heating and cooling energy requirements. The purpose of the present study is to determine the effect of envelope parameters: orientation, external walls, glazing, shadings, glass-to-wall ratio, surface absorbance of external walls (color), roofs, upon energy saving and conservation for a typical office building in Madrid.

7786 (IBP-WB–7/87) **Are the pre-calculated K_{eff} values of outside components confirmed in practice?.** Erhorn, H.; Gertis, K.; Rath, J.; Wagner, J. Fraunhofer-Institut fuer Bauphysik, Stuttgart (Germany, F.R.). Bereich Waerme/Klima. 1987. 15p. (In German). Available from Copy held by UB/TIB Hannover.

The simple k_{eff} method is suitable for the quantification of the heating energy demand of buildings. The reason why it is used too rarely is that the validity of this method has been occasionally queried in the literature, as it has so far only been based on calculated results. To confirm the calculated results, this k_{eff} method was therefore checked by measurements in average German climatic conditions. Data are given on the k_{eff} of windows, walls and roofs. The construction and execution of the experiment and the results are described and generalised. Measured k_{eff} values are submitted and practical conclusions (the method of calculation is sufficiently accurate for designing buildings) are drawn. (HWJ).

7787 (IBP-WB–9/87) **Do computer calculations of the termal behaviour of buildings agree with practical measurements?.** Erhorn, H.; Gertis, K.; Rath, J.; Wagner, J. Fraunhofer-Institut fuer Bauphysik, Stuttgart (Germany, F.R.). Bereich Waerme/Klima; Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). 29 May 1987. 35p. (In German). Contract BMFT 03E-4460-A. Order Number DE90732471. Available from NTIS (US Sales Only), PC A03/MF A01.

The thermal behaviour of buildings can be described by their heat energy consumption and their room air tempeature. Determining these parameters can be done by calculation or by measurement. While previously only static processes of calculation were used for this, recently more and more frequent predictions have been made with dynamic computer models. Due to the very large quantity of data which is made available, the impression can easily be created that this must be a very accurate calculation. Comparative investigations for assessing the accuracy of the result were previously only done in isolation and with very different degrees of detailing. (orig./BWI) With 5 tabs., 14 figs.

7788 (JSES–8801, pp. 77-80) **Study on open-cycle solar absorption dehumidifying/drying system. (Part 3. Experiments of dryness storage tank).** Kimura, Ken'ichi (Waseda Univ., Tokyo, Japan); Sai, Kokan; Uda, Yasuhiro; Somekawa, Nobuyuki; Muramatsu, Hiroshi. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Two dryness storage tanks are required for the previously reported solar absorption dehumidifying/drying system. This is a report on the experiment made on the first dryness storage tank. A cylinder shaped tank was designed, and an acrylic model was fabricated. The fixed outlet was positioned only at the top, and the inlets of thick LiCl water solution were positioned at the top, middle and bottom of the tank. In the case of the upper inlet, the introduced thick solution was mixed in the upper part, and proceeded to the outlet. In the case of the middle inlet, low concentration solution remained in the lower part. As regards the lower inlet, the temperature became fairly uniform within the tank, but the concentration became slightly higher in the lower part. Continuous measurement of the change in the concentration of LiCl in the layers is not easy. A correcting method for the measured values can be thought of in which the standard concentration of LiCl water solution is measured beforehand by a highly accurate digital measurement instrument, the concentration of the actually used solution is measured by another measuring instrument, and the latter result is compared with the former after the experiment. 6 refs., 12 figs.

7789 (JSES–8801, pp. 81-84) **Evaluations of performance for hybrid solar house N. (Part 2. Soil thermal storage and heating).** Nakajima, Yasutaka (Kogakuin Univ., Tokyo (Japan)); Yoshida, Naohiro. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

The performance of thermal storage and heating systems of a hybrid solar house which has both active and passive systems were evaluated. The thermal storage experiment was carried out for 4 months from September to December. The Standard temperature of 40^0C was employed for the thermal storage operation considering the past experience and the result of a simulation. The heat was stored in soil and 3 tanks whose temperature levels were different. The heating experiment was performed from January to March, and the majority of the measurements was made in March. The operated heating systems were a floor heating system which used the hot water stored in a high temperature heat storage tank, and a high efficiency heat pump which utilized the air temperature in the heat storage tank as well as the soil temperature, and their heating efficiencies were analyzed. In the experiment carried out this time, heat storage was not satisfactory because of the shade produced by trees, but the performance of the basic heat storage operation was clarified. 4 refs., 11 figs., 1 tab.

7790 (JSES–8801, pp. 89-92) **Study on the thermal performance of the passive air cycle house. (Part 4. Comparison of the thermal performance in heating between the conventional heat insulated house and PAC house).** Ishihara, Osamu (Kumamoto Univ. (Japan)); Sugai, Takashi; Ninomiya, Hideyo. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Thermal performances of 3 test houses (conventional insulated house and 2 PAC houses) are reported. Under the normal condition, the magnitudes of the maximum temperature difference at 2 PM between the northern room and the southern room were in the order of the conventional insulated house, outside insulated house and PAC house, regardless of the opening or closing of rain doors. If the northern and southern rooms were heated, little difference was observed in the temperature between the PAC house and outside insulated house. When those rooms were not heated, the room temperatures were different between the conventional heat insulated house and the PAC house, and the PAC house showed higher temperature in the garret and under the floor. Comparison of the temperature variation in the non-heated northern room, under the condition of heating the southern room only, showed that temperature difference between the two rooms was less with the PAC house. The room temperature of the conventional insulated house with closed ventilation openings in the garret and under the floor was higher by approximately 2 - 4°C in midnight and the daytime. PAC houses are less influenced by the decrease in the outdoor temperature than the conventional insulated house. 8 figs.

7791 (JSES–8801, pp. 93-96) **Study on the thermal performance of the passive air cycle house. (Part 5). Investigation and analysis on the amenity of the PAC house by the questionnaire.** Ishihara, Osamu (Kumamoto Univ. (Japan)); Mori, Yurika; Yoshihara, Naomi; Nakamura, Sachiko. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint Conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

A survey was conducted on the residents living in passive air cycle houses (PAC) to carry out a survey on the opening and shutting of the ventilating openings in the garrets and under the floors, amenity in winter and summer, etc. The questionnaires were sent to 354 households. The matters for investigation were the outline of the house, appraisal of thermal environment, kinds of air conditioners, humidity in rooms, energy consumption, etc. The average areas were about 150 m^2, 300$m^2$and 100m^2 for the building, site

and total floor respectively. The majority of the residents replied that they open the ventilating openings in May and close them in November. 86% of them stated that the passive air cycle house is very much cooler or slightly cooler in summer than the conventional house. 93% replied very much warmer or slightly warmer in winter. 3 figs., 5 tabs.

7792 (JSES–8801, pp. 97-100) **Experimental study on operating performance of a heat pump system using earth tube for residential space heating and cooling. (Part 1. Experimental outline and preliminary experimental results).** Nagatomo, Muneshige (Tohoku Univ., Sendai (Japan)); Yoshino, Hiroshi; Ishikawa, Yoshimi; Kimura, Shigeo; Watanabe, Misao. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Reports are made on the outline of the experiment carried out on a heat pump system which uses a tube embedded in the earth, the result of the experiment for the study of heat exchange characteristics of the earth tube, and the result of the cooling test made in summer. A test passive solar house and a 34 m long, 20 cm diameter hard vinyl chloride earth tube embedded 1 meter deep in the earth were used for the experiment. The items measured were: temperatures at the inlets and outlets of the evaporator of the heat pump, the condenser and the embedded tube; temperature of the earth surrounding the embedded tube; power consumptions of the heat pump and the fan for the embedded tube, etc. The air temperature obtained from the embedded tube was confirmed to have a very high linear relation with the inlet air temperature which is proportional to the temperature of the earth, and it was confirmed that the thermal energy can be extracted by the embedded tube. The cooling coefficient of performance of the heat pump was found to decrease with the increase in the temperature difference between the air in the condenser and the air in the evaporator. 4 refs., 6 figs., 3 tabs.

7793 (JSES–8801, pp. 101-104) **Study on the thermal performance of refrigerant direct expansion radiator/collector employed in solar-assisted heat pump system.** Ryu, Yuzi (Kyushu Univ., Fukuoka (Japan)); Urano, Yoshimi; Watanabe, Toshiyuki; Minami, Arinari. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

The efficiency of the solar-assisted air source (sol-air) heat pump system depends on the thermal property of its direct expansion radiator/collector. Computer simulations were carried out to study the method of improving the system efficiency by the improvement of thermal performance in summer and decreased refrigerant condensation temperature, taking advantage of the evaporation water and radiation cooling by watering the radiator/collector panel. The effects of perpendicular fins on the panel, evaporation of water on the panel surface, and the surface absorption rate of solar irradiation on the heat dissipation of the panel are shown in figures. The perpendicular fins increased the amount of heat dissipation by approximately 25%, and evaporation of water approximately 140%. The panel with the solar absorption rate limited to 0.3 which uses the evaporation of water showed the maximum amount of radiation, and the radiation of approximately 800 k cal/m^2h can be expected at the condensing temperature of 40°C. 2 refs., 12 figs.

7794 (JSES–8801, pp. 105-108) **Study on optimum operation method of sol-air heat pump system. (Part 2. Result of winter and summer experiments).** Nakajima, Yasutaka (Koqakuin Univ., Tokyo (Japan)); Shiraishi, Kiichi; Shioya, Masaki; Takemura, Akihiro; Ohashi Kazumasa. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Preliminary wintertime experiment and summertime experiment were carried out to obtain fundamental data for the heat source, and analysis and estimation were made for the operational characteristics of sol-air panel, heat storage tank, system, etc. The amount of heat collection by a panel changes with the environmental conditions (weather). A measuring instrument was used for the measurement, and the amount was calculated by a formula with the heat balance of the panel taken into consideration.For the estimation of water temperature in the tank, the amount of heat calculated on the assumption that the heat transfer is set to a steady state and all the heat is transferred to water from the refrigerant. The estimated value agreed well with the measured value. In the experiment, coefficient of performance (COP) of 2.8-3.9 and the seasonal COP of 3.3 were achieved. As a rule, COP improves with the increase in the amount solar irradiation. When the heat dissipation of the panel is the cooling cycle is taken into consideration, the heat dissipation capacity depends on the condensation temperature of the refrigerant, although it is a little influenced by environmental conditions. The capacity is within a certain range (approximately 21000-27000 k cal/h) with little variation. 6 refs., 13 figs., 3 tabs.

7795 (JSES–8801, pp. 113-116) **Thermal energy storage by chemical heat pump using $CaCi_2$-NH_3-NH_4 NO_3 system.** Ito, Shigeru (Science Univ. of Tokyo (Japan)); Kato, Tadayoshi; Yoneda, Noboru. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

The storage temperature of the previously reported chemical heat pump system using NH_3 as the active medium seems to be a little high for storing solar energy. Therefore, a chemical heat pump was fabricated which uses $CaCl_2.8NH_3$ and liquid ammoniate $NH_4NO_3nNH_3$ as high and low temperature materials respectively. As a result, thermal storage at as low as 75° C was realized, storing 210 KJ heat which was 50% of the theoretical amount of thermal energy storage. 6 hours are required for thermal energy storage, and 2 hours for heat dissipation, which can be said as standard for a chemical heat pump for thermal energy storage. What is more, thermal energy storage could by performed at above 75° C on the high temperature side, and below 20° C on the low temperature side. Heat dissipation could be made at above 0° C on the low temperature side. The temperatures differed considerably between the high and low temperature sides. No degradation of the performance was observed even after 20 cycles of operation, and the present system can well be put to practical use. The reaction system of the study is introduced. 2 refs., 6 figs., 2 tabs.

7796 (JSES–8801, pp. 117-120) **Characteristics of an air-conditioning system with an adsorption-type refrigerator.** Ito, Sadasuke (Kanagawa Inst. Tech. (Japan)); Miura, Naokatu; Sanpei, Tsuyoshi. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

An adsorption type refrigerator which can operate with relatively low water temperature of about 70° C was installed and operated in an actual air conditioning system. The result of the experiment and the characteristics of the system are presented.The system is so designed that a part of the hot water returns to the heat exchanger, bypassing the refrigerator. Free surface levels must be the same in the buffer tank, expansion tank, and refrigerator because the path of the cold water and cooling water as well as that of the hot water and cooling water are temporarily connected in this system.Careful consideration must by given not to decrease the degree of vacuum because low degree of vacuum decreases both COP and refrigerating capacity. It was not possible to keep a constant inlet temperature by the boiler and heat exchanger because the hot water outlet temperature fluctuated very much with time. This seems to be one of the reason why the expected COP could not be obtained. The adsorption and desorption tanks have great effect on the COP and refrigerating capacity. 1 ref., 7 figs.

7797 (JSES–8801, pp. 169-172) **Study on a system utilizing solar beam natural lighting.** Ishida, Masaharu (Yazaki Sogyo

Kabushiki Kaisha (Japan)); Takahashi, Nobuyuki. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

Concerning solar beam natural lighting systems for creating amenity by introducing the sunlight indoors, there are the (sun) tracking type and the non-tracking type, but this study aimed at developing a non-tracking type of reasonable cost and highly reliable. With regard to the non-tracking system, its light collecting opening is normally installed facing due south and its efficiency shows a sharp peak during a short time belt around the time when the sun comes due south, but drops sharply in the time belt before and after the above. In this study, the most fundamental natural lighting system, namely the internal reflection light duct system was selected and its fundamental characteristics were investigated. In addition, in order to improve the above defect, a system was designed to improve light collecting efficiency by installing a composite prism at the light collecting opening and the characteristics of the above system was tested. Hard urethane reflection boards were used for the light duct, a raintight cover was set on the light collecting opening, the duct, about 8m long and with its inner size of 120X270mm, was installed at the ceiling of the second floor of a three-story experimental house and measurements were conducted. As a result, because of repeating reflections caused by the reflection films of the internal surface of the light duct, decay of the light was big. 6 figs.

7798 (JSES–8801, pp. 225-228) **Self-contained house using energy of nature by combining solar heat and radiation cooling.** Saito, Takeo (Tohoku Univ., Sendai (Japan)); Kuwabara, Kimihito; Yoshioka, Masahiro. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

This study proposes a self-contained house using energy of nature by combining solar heat, underground cool heat and atmospheric radiation cooling, etc. as alternate energy sources in order to fulfill almost 100% of energy for air conditioning and hot water supply by energy of nature for the standard family in Japan. In other words, the house above is designed to have two working modes namely long term hot heat storage by using solar collectors and long term cold heat storage by using sky radiators. The house also has a large underground heat storage tank (about 40m^3) which is used for two purposes of storing the above hot heat as well as cold heat. Throughout a year, energy of nature alone fulfills about 100% of the energy needed for air conditioning and hot water supply of the above house. The total energy which this self-contained house can supply throughout a year is 1,500- 1,800 Kcal. 12 refs., 9 figs., 2 tabs.

7799 (JSES–8801, pp. 229-232) **Study concerning heat capacity in direct-gain system and energy consumption of auxiliary heating (No. 11). Arrangement and effectiveness of heat reservoir.** Ito, Naoaki (Tokyo Metropolitan Univ. (Japan)); Sunaga, Yasumichi. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

It is considered that effectiveness of heat capacity in a house using the direct gain system is affected by whether a heat reservoir receives direct reaching insolation or not. This article is a report of the study by simulation on the effects of the interior arrangement of heat reservoirs on the effectiveness of auxiliary heating calories and heat capacity. The calculation program used for the simulation has a feature to segment one surface such as wall into 25 sections and calculate in judging whether each of the sections receives direct reaching insolation or not. The building model used was as large as 8 straw mats and had a simple form with its side facing south totally open. Each of its walls was made of insulator and heat reservoir, concrete only and its window panes were double layer glasses. As a result, it was revealed that even for the same heat capacity, the effects of the positions of heat reservoirs on the auxiliary heating calorie were different and the effectiveness of heating capacity was greatly affected by the heating value of insolation which the surface of the heat reservoir received. 3 refs., 9 figs., 2 tabs.

7800 (JSES–8801, pp. 233-236) **Completely self-contained house. Its outline and effect of PCM heat storing panel.** Fujii, Ishine (Meiji Univ. School of Engineering, Tokyo (Japan)); Yano, Naotatsu; Kimura, Makoto. Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

This is a report on the outline of the model house which was built at the elevation of about 1,000m on the foot of Mt. Yatsugatake and the effect of a PCM heat-storing panel utilizing latent heat of dissolution. This house has the total floor area of 101m^2, uses 20cm thick glass wool insulators for walls, floors and ceilings, etc., triple glasses for doors and windows and its fittings are all wood. 8 ceiling windows of 1m^2 each are installed and also are arranged on the floors where the sunlight through the ceiling windows is projected PCM heat storing panels utilizing latent heat which makes solid/liquid phase change at about 18^{0}C. Electric power necessary for lighting at night, operation of refrigerator and ventilating fan and pumping up well water is supplied with a solar cell module (maximum output is about 49W) on the roof and as for sanitary facility, the system using vegetative microorganism which was developed in Northern Europe is used. Experiments showed that the effect of PCM panel was not clear when the outdoor temperature was over 20°C, but became significant at and below that temperature. 11 figs., 2 tabs.

7801 (JSES–8801, pp. 237-240) **Heat-emission characteristics of latent heat accumulator having heat exchanger tube with cross fins.** Sasaguchi, Kengo (Kumamoto Univ. (Japan)). Japan Solar Energy Society, Tokyo (Japan). 1 Dec 1988. (In Japanese). (CONF-881297–Absts.: 1988 JSES and JWEA joint conference, Kumamoto (Japan), 1-2 Dec 1988). In *Abstracts of 1988 JSES-JWEA Joint conference.* Order Number DE89900544. Available from NTIS (US Sales Only), PC A14/MF A01.

The reliable and effective method for improving heat transfer characteristics of a latent heat accumulator using phase change material (PCM) with large heat storage density is the method to use finned tubes concerning which there are a heat exchanger tube with fins arranged in the direction of the tube axis and a heat exchanger tube with cross fins arranged in the vertical direction to the tube axis. In this study, a model was proposed which could predict relatively simply, though approximation, overall characteristics of a latent heat accumulator having a heat exchanger tube with cross fins which had never been studied due to various difficulties. The effects of various parameters on the overall characteristics of a latent heat accumulator having a heat exchanger tube with cross fins were also clarified through calculation based upon the above model. Concerning the effect of each parameter on the heat emission characteristics, the effects of the parameters of NTU, physical property and shape, etc. are reported. 7 refs., 10 figs.

7802 (MLWIA–CE-02808) **Integration I - User-friendly Computerized Building Management System annual report (1984/1985).** Wong, L. (MLW Interspace Automation Ltd., Edmonton, AB (Canada)). MLW Interspace Automation Ltd., Edmonton, AB (Canada). 1985. 20p. (CE–02808). Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

This report discusses the objectives, goals, and project development of an easy-to-use and inexpensive microprocessor-based building management system prototype. The salient features of the system, include remote programmable controller and a monitoring control centre. The system provides total integration of all standard control functions such as sequential control, logic interlock, modulation control and floating point signal conditining functions. The results of the bench testing are summarised, and recommendations for digital control for small and medium-sized buildings are provided.

7803 (NRC/IRC–CR55051) **Testing of air barrier systems for wood frame walls: Client report.** National Research Council of Canada, Saskatoon, SK (Canada). Inst. for Research in Construction. 3 Jun 1988. 94p. (MICROLOG–89-04275). Available from PC Environment Canada. Environmental Protection Publications, 10 Wellington St., 12th PVM, Ottawa, ON, CAN K1A 0H3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

Air leakage in a building can be controlled by an air barrier system. i.e., a continuous plane of air tightness designed and constructed into the building envelope. This plane of air tightness may be achieved with a single strong air-tight material or a combination of materials. In either case, the assembly must be structuraly capable of withstanding the air pressure load exerted on the building envelope. The objective of this project was to measure the air leakage and structural performance of air barrier systems intended for use in wood frame walls. Measurements were performed using a test apparatus and procedure which were developed at Institute of Research in Construction (IRC). Ten specimens were tested - nine constructed with wood studs and one constructed with steel studs. All test specimens, save one, were constructed at IRC using methods approved by the Canadian Mortgage and Housing Corporation. The final specimen was prefabricated by the manufacturer. For eight of the ten specimens tested pressure differences measured indicated laminar flow. This indicates these specimens are leaking through porous materials or very tight joints. Two specimens exhilited turbulent flow indicative of a combination of flow regimes. Eight specimens passed all steps of the negative pressure difference structural test. Two were too leaky to test. Seven specimens failed the positive pressure difference test, mostly at fasteners. Most specimens would have passed with modified fasteners. 50 figs., 20 tabs.

7804 (OH/RD–88-213-K) **Reliability assessment of the HVAC system for the Clarkson system control center.** Wang, L. Ontario Hydro Research Div., Toronto, ON (Canada). 27 Sep 1988. 13p. (MICROLOG–89-04559). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

A reliability assessment was carried out for the heating, ventilating and air-conditioning system to be installed at the new System Control Center at Clarkson. The predicted unavailabilities and mean times between failures for the critical load areas are within the specified reliability targets. The computed mean downtimes for the computer room and the electrical equipment room are longer than the target value of 0.5 h, which may not be attainable for a practical HVAC system. 4 figs., 3 tabs

7805 (OH/RD–MSDD87-13) **Residential appliance survey 1986.** Ontario Hydro Research Div., Toronto, ON (Canada). Jun 1987. 29p. (MICROLOG–89-04747). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

This report provides the results of the 13th Ontario survey, analysing appliance ownership in Ontario homes. The survey was conducted by mail and had a response rate of 48.4% without a follow-up mailing, up from 36% in 1983 and 45% in 1980. The survey continues the data base begun in 1960, providing appliance ownership information by individual participating municipal utilities and each of Ontario Hydro's rural retail areas. The data is also used as an input to the residential end-use energy planning system, a residential electricity forecasting model being evaluated by Ontario Hydro. The survey measures the effects of household characteristics and appliance ownership on electricity consumption and measures conversion and replacement rates of water and space heating systems. The report also supplies trends in appliance saturation from 1960-1986. A description of the survey method, with sample characteristics and response and a sample questionnaire, are also included. 4 figs., 12 tabs.

7806 (ORF/ES–CE-02802) **Residential exhaust equipment: A research report.** Ontario Research Foundation, Mississauga, ON (Canada). Energy Systems Centre. 12 Sep 1988. vp. (CE–02802). Available from Canada Mortgage and Housing Corporation, Annex Bldg., 628 Montreal Rd., Ottawa, ON, CAN K1A 0P7. Prices: PRICES UPON REQUEST.

This report is a simplified builder guide describing exhaust fan products and systems to achieve more effective and acceptable residential exhaust systems. It includes a review of exhaust system practice and products in Canada and abroad. Field observations on and testing of field installed systems in four major centres across Canada and a laboratory testing phase to evaluate the air flow performance of both common components and systems are described. A literature search revealed the European and far Eastern exhaust systems differ from North American units, and central systems are prevalent in Europe, while Japanese fans tend to be through-the-wall. The bathroom fan systems were measured at an average of 44% and kitchen fans were at an average of 38% of their rated flow. The guide highlights the flow deficiencies, and recommends the use of certified equipment installed to manufacturer's specifications. Three appendices are included.

7807 (ORNL/Sub–84-47989/4) **Absorption fluids data survey: 1989 update: Topical report (First update of final report on worldwide data).** Macriss, R.A. (Institute of Gas Technology, Chicago, IL (USA)); Zawacki, T.S. Oak Ridge National Lab., TN (USA); Institute of Gas Technology, Chicago, IL (USA). [1989]. 40p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC05-84OR21400. Order Number DE90003985. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This is an update of a series of prior reports on absorption fluids and data, ORNL/Sub/84-47989/1, 2, & 3. It covers additional data developed and published mainly during 1985–88, and cites 44 additional references. Seventy-four different worldwide publications containing data relating to properties of binary, ternary, and multicomponent absorption fluids were identified. Of these, 30 manuscripts include applications of absorption fluid properties data toward evaluation, assessment, or design of chillers or heat pumps but do not include actual fluid properties data. The remaining 44 publications date as far back as 1929, but over 50% of these documents were published between 1985 and 1988. The texts of the 44 manuscripts are in English, German, Japanese, Russian, or French. The absorption fluids discussed in the 44 documents are combinations of 9 different "refrigerant" compounds and 30 single, 7 binary, and 1 ternary "absorbent" compounds. 44 refs., 21 tabs.

7808 (SV-UL–89-14) **Comparison between three heat emitting floor slips for water-borne heating.** Sjoeberg, M. Statens Provningsanstalt, Boraas (Sweden). 31 Mar 1989. 9p. (In Swedish). Order Number DE90728298. Available from NTIS (US Sales Only), PC A02/MF A01.

In connection with conversion of electrically heated detached houses to water-borne heating, so-called heating slips or base convectors are an alternative for conventional radiators. Performance of two fabricates of heating slips were tested at the State Power Board's Aelvkarleby laboratory. The heat emission was 100 W//m for two of the test objects and 65 W/m for the third, all measurement at 60 deg C fillet temperature and 20 deg C room temperature. In addition the directive operative tempeature according to Swedish Building Standard 1980 was estimated for some of the rooms in a detached house from 1968. The calculations were done both for heating slips and conventional radiators below windows. The results indicate that the minimum demand of 18 deg C directive operative temperature probably not will be met with heating slips as sole heat source in the type of house in question.

7809 (VTT-TIED–991) **Research program on renovation 1986-1988: Summary report 1. Initial information of renovation.** Aikkila, A. (Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). Rakennetekniikan Lab.); Lehtinen, E.; Levon, B.V. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). Jul 1989. 80p. (In Finnish). Order Number DE90728187. Available from NTIS (US Sales Only), PC A05/MF A01.

The aim of the building renovation project undertaken by the Technical Research Centre of Finland was to gather together data on renovation techniques applicable to certain aspects of postwar buildings and infrastructure. The project, carried out in 1986-1988, was divided into four sections: Initial data required for renovation

purposes, Renovation and inspection techniques, Town and residential suburbs as targets for renovation, and Direction of road and street maintenance. In brief, the results obtained in Initial data required for renovation purposes were the following: A model for predicting the building materials requirement created by renovation schemes was developed for long-term inspection purposes. A basic file was compiled on the amounts and types of such materials needed for the repair of buildings of different kinds and ages. A data file was created describing apartment buildings constructed between 1940 and 1975, their designs, structures, norms and constructional methods employed. This type of building will become one of the most common targets for renovation in the near future. Statistics on the renovation of buildings in Finland are sporadic and incomplete and thus incorporate a risk of erroneous conclusions being drawn from them. A data file was created on the major building materials and structures used in Finland from the point of view of their durability and susceptibility to damage. A knowledge of the types of damage and wear to be expected forms and essential basis for the systematics of the life cycle of buildings. The file can also be used for laboratory modelling of the life expectancy of buildings. The planning documents for renovation schemes are frequently unsatisfactory, expecially where building specifications are concerned. A computer file of general quality standards for renovation schemes should be drawn up.

7810 (VTT-TIED–1050) **The need for a vapour barrier in a wooden wall.** Niininen, J. (Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). Rakennetekniikan Lab.). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). Sep 1989. 64p. (In Finnish). Order Number DE90728184. Available from NTIS (US Sales Only), PC A04/MF A01.

In this study, the need for a plastic film vapour barrier in wooden walls, moisture and its effects on the behaviour of wooden structures as well as the use of loose-fill insulation in wooden walls were investigated. Wood-framed external walls of single-family houses under Finland's climatic conditions can with certain reservations be built without a plastic film vapour barrier. This is possible provided that the structures have a good degree of airtightness. In order to avoid problems caused by possible wintertime built-up of moisture within the wall structure, the wall should be provided with a ventilation gap right behind the external cladding to ensure sufficient removal of humidity. Due attention should also be paid to the installation of wind barriers and light-weight, air-permeable thermal insulation materials. The wintertime dryness of indoor air can not be affected by using a wooden wall structure without a vapour barrier. The structures under investigation showed a rather low moisture storing capacity, and transfer of moisture from the wall into indoor air is not possible during winter. In practice, airleakages through wooden walls without vapour barrier take place the same ways as through ordinary walls with plastic film vapour barrier. Settlement of loose-fill cellulose fibre insulation in wall structures is a problem even with high insulation density. Insulation faults caused by poor quality of workmanship were found regardless of the insulation material.

7811 (VTT-TUTK–620) **Feasibility of cool storage systems in refrigeration.** ElMahgary, Y. (Valtion Teknillinen Tutkimuskeskus (Finland) Saehkoe- ja Automaatiotekniikan Lab.); Kekkonen, V.; Laitinen, A.; Pihala, H. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). May 1989. 81p. Order Number DE90728179. Available from NTIS (US Sales Only), PC A05/MF A01.

In the present report, the economic viability and technical feasibility of selected cool storage systems are considered. Cool storage has clear potential for several applications: in connection with air-conditioning systems, domestic refrigerating and freezing systems; commercially e.g., in the dairy and vegetable industries; and in deep freezing, as in the meat industry. Air-conditioning has limited significance in Finland. For this reason it was not investigated in this study. In domestic refrigeration and freezing two systems were investigated; a controlled cooling/heating system and a simple built-in system in individual redrigerators and freezers. The ccentral cooling/heating system in houses was found to be economically unattractive. It also has several technical drawbacks. The simple built-in system appeared to be promising. The amount of savings is rationally a function of the difference between day and night tariffs and the costs of installing an automatic switch and storage media. In the vegetable and dairy industries cool storage also has considerable potential. Several systems were investigated in this respect and compared to the conventional system. The cool storage system using Cristopia balls, one of the most common commercial systems available in Europe, was not economical at a tariff difference of 10 p/k Wh or more. Cool storage for freezing in meat plants was also investigated. Again, in view of the relatively high costs of the Cristopia balls, the connection of such a cool storage system to existing plants was economically unattractive. Cheaper cool storage systems may be more attractive. On the other hand, even the cool storage system using Cristopia balls was found to be economically attractive when its size was optimized with the plant power in a new plant. When the net annual savings were about FIM 170 000 and the pay back period was about 6 years.

7812 (VTT-TUTK–625) **Measurement of reflection and impedance in a beam by the structural intensity technique.** Lahti, T. (Valtion Teknillinen Tutkimuskeskus (Finland). Instrumenttitekniikan Lab.); Linjama, J. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). Jun 1989. 66p. Order Number DE90728212. Available from NTIS (US Sales Only), PC A04/MF A01.

In the one-dimensional propagation of vibration energy, the structural intensity methods can be extended to the determination of the mechanical impedance and reflection coefficient. A short survey of respective measurement of acoustic impedance is presented, and the principles of structural intensity measurements in beams are reviewed. Then, analogously to acoustics, frequency domain expressions are derived for estimating the impedance and reflection coefficient in a beam. The developed techniques are also extended to a special application, the division of the partly reflective general field into perfectly propagating and standing parts. Separation based on the reflection coefficient is suggested and compared to a known impedance-based approach. In laboratory experiments with bending waves in a simple beam, the various methods for estimating the impedance and reflection coefficient were tested and compared. The known method of measuring reflection of sound waves in ducts was shown to be applicable in beams. The simplest suggested method for estimating the impedance, which was based on the known wave impedance and the estimated reflection coefficient, gave the most reliable results. Also the character of the field separation methods was demonstrated in the experiments. The method based on the reflection coefficient appeared preferable, but the disadvantange is that it cannot be applied in fields with more than one dimensions.

7813 **Measurement of solar heat gains from short-term energy monitoring: Results from four buildings. .** Subbarao, K. (Solar Energy Research Inst., Golden, CO (USA)); Burch, J.D.; Hancock, C.E.; Lekov, A.; Balcomb, J.D. pp. 488 of Proceedings of Solar 89, the 14th national passive solar conference. American Solar Energy Society, New York, NY (1989). (CONF-8906165–: 14. national passive solar conference, Denver, CO (USA), 19-22 Jun 1989).

The Solar Energy Research Institute (SERI) has been carrying out a project on building monitoring. The initial focus of the project has been on long-term performance prediction through short-term tests in residential buildings. Starting with hourly data on a small number (about 20) of channels taken over a short period (a few days) the method extracts the necessary parameters from which long-term extrapolation can be done through an hourly simulation of the as-built building. Applications include a measurement-based energy rating of the house as well as retrofit assessment. In this article, a comparison of solar gains obtained from the performance data analysis and from simulation model derived from a site visit is made for four buildings. In general, the audit description tends to overestimate the solar gains, sometimes quite seriously. The phases of solar gains are also compared. Substantial errors in the predicted loads are possible unless the building statics as well as solar dynamics are obtained from measurements. The importance of measurement-based performance assessment, in particular of the solar performance, and the applicability of their short-term energy monitoring (STEM) procedure emerge from this study.

7814 **Opportunities for efficiency improvements and load shaping revealed by hourly end-use electrical energy consumption data.** Stoops, J.L. (Pacific Northwest Labs., Richland, WA

(US)). vp of The 8th Miami international conference on alternative energy sources. Volume 1-2 (Condensed Papers). Vezioglu, T.N. Clean Energy Research Inst. University of Miami, Coral Gables, FL (1988). (CONF-871204–: 8. Miami international conference on alternative energy sources, Miami Beach, FL (USA), 14-16 Dec 1987).

Analysis of the hourly end-use electrical consumption data collected for the Bonneville Power Administration and the United States Department of Energy as part of the End-use Load and Conservation Assessment Program (ELCAP) and co-instrumentation studies have revealed apparent opportunities for improvements in the energy efficient operation of the buildings. In particular the demand impacts from particular control strategies are clearly revealed by the data as are control deficiencies of some systems as installed and operated. Analysis of the data indicates that relatively minor modifications to control strategies could have pronounced affect on the load shapes of the buildings. Graphical analysis and data presentation techniques are applied to present these results from the extremely large and detailed data sets. The data itself is used to identify and sort by day-type and then to normalize, revealing consistent and repeating opportunities for efficiency improvements. The sorting procedures simplify the data sets by removing some of the variability determined by time dimensions. Powerful computerized graphical presentation techniques are then applied in customized analysis routines, to produce revealing graphical data summaries. The resulting analysis reveals specific opportunities for energy management induced load shaping and efficiency improvements.

7815 **Measured energy performance of commercial buildings: Past BECA results and recent findings on cool storage.** . Piette, M.A. (Lawrence Berkeley Lab., Berkeley, CA (US)); Wyatt, E.; Akbari, H.; Harris, J. vp of The 8th Miami international conference on alternative energy sources. Volume 1-2 (Condensed Papers). Vezioglu, T.N. Clean Energy Research Inst. University of Miami, Coral Gables, FL (1988). DOE Contract AC03-76SF00098. (CONF-871204–: 8. Miami international conference on alternative energy sources, Miami Beach, FL (USA), 14-16 Dec 1987).

The Buildings Energy Data Group at Lawrence Berkeley Laboratory has compiled and analyzed measured energy performance data for over 450 commercial buildings which have had various conservation strategies implemented. These data are contained in the BECA (Buildings Energy Use Compilation and Analysis) data bases. The commercial elements of the BECA data bases are organized into three subsets, BECA-CR, -CN, and -LM. BECA-CR contains pre- and post-energy consumption data on over 300 retrofitted commercial buildings. For the 94% of the buildings that saved site energy (k kWh = 3413 Btu), the median savings was 31 KBtu/ft^2-year, or about 25% of the pre-retrofit energy use. BECA-CN contains data on 152 new commercial buildings designed to utilize various energy saving features. For most of the buildings the energy consumption data consist of whole-building utility bills, although more detailed end-use (e.g. heating, lighting, etc.) data are available for some. Recent efforts have focused on assessing commercial cool storage systems. As part of BECA-LM (load management), submetered performance data and system costs have been collected for about 10 buildings with cool storage systems.

7816 **Modeling complex daylighting with DOE2.1C.** Baker, M.S. (Oregon Dept. of Energy, Salem, OR (US)). pp. 488 of Proceedings of Solar 89, the 14th national passive solar conference. American Solar Energy Society, New York, NY (1989). (CONF-8906165–: 14. national passive solar conference, Denver, CO (USA), 19-22 Jun 1989).

Daylighting is often proposed as an energy conversation strategy in new commercial buildings. However, most building energy analysis tools (computer simulations) have rather significant limitations regarding daylighting analysis. This paper describes a daylighting analysis technique using some powerful and generally unused features of the DOE2.1C computer program in combination with scale building models and/or detailed daylighting calculations. This method was used to model and analyze various daylighting options in several new utility office buildings constructed in Oregon. A comparison of modeled and preliminary monitored building data is presented.

7817 **A comparison of two daylit offices in Eugene, Oregon.** Perry, J. (Oregon Dept. of Energy, Salem, OR (US)). pp. 488 of Proceedings of Solar 89, the 14th national passive solar conference. American Solar Energy Society, New York, NY (1989). (CONF-8906165–: 14. national passive solar conference, Denver, CO (USA), 19-22 Jun 1989).

Two new daylit office buildings were recently built in Eugene, Oregon. They house the administrative functions of two energy-conscious public utilities. Despite similarities in purpose, the buildings are quite different. This paper documents the design process, describes the buildings, and discusses the energy impacts and draws some conclusions about what worked and what did not work.

7818 **Ventilation air tempering with ground- and surface water.** Spolek, G.A. (Graig Spolek and Associates, Inc., 2734 NE 23, Portland, OR (US)); Peterson, J.C.; Grill, A.R. vp of The 8th Miami international conference on alternative energy sources. Volume 1-2 (Condensed Papers). Vezioglu, T.N. Clean Energy Research Inst. University of Miami, Coral Gables, FL (1988). (CONF-871204–: 8. Miami international conference on alternative energy sources, Miami Beach, FL (USA), 14-16 Dec 1987).

If the fresh air supplied to a building is first passed over an air-water heat exchanger and tempered to moderate conditions, space conditioning energy can be reduced. To do this, only a heat exchanger and the associated piping to access the body of water are required to retrofit an existing building. A demonstration project of the air tempering concept was performed at Albany General Hospital in Albany, OR. In that application, well water was supplied at 59F to precondition the inlet air. The system cost $50,000 to install and was estimated to save $8,000 per month in energy costs. The success reported for the project prompted this study. While not all buildings have the same mechanical system and water availability, all do require ventilation with fresh air which must be heated or cooled to meet space comfort conditions. This study evaluates the energy conservation potential if air tempering were used on a large scale throughout the Pacific Northwest.

7819 **A simple model of atmospheric radiation for the study of high-technology glazing performance in passive solar buildings.** Wray, W.O. (Advanced Engineering Technology, Los Alamos National Lab., Los Alamos, NM (US)); Best, E.D. pp. 488 of Proceedings of Solar 89, the 14th national passive solar conference. American Solar Energy Society, New York, NY (1989). (CONF-8906165–: 14. national passive solar conference, Denver, CO (USA), 19-22 Jun 1989).

High-technology glazings that transmit more solar radiation or reduce heat loss through the glazing are being developed for passive solar buildings. The authors present a method for incorporating these new glazing characteristics into an existing design tool, the Fast Solar Load Ratio method. The enhanced method uses a simple model of atmospheric radiation and an analytic function to calculate transmission characteristics.

7820 **Daily advanced window performance from a spectral model.** Soule, D.E. (Solar Energy Research Inst., Golden, CO (USA)). pp. 488 of Proceedings of Solar 89, the 14th national passive solar conference. American Solar Energy Society, New York, NY (1989). (CONF-8906165–: 14. national passive solar conference, Denver, CO (USA), 19-22 Jun 1989).

A spectral model developed for advanced multilite spectrally selective windows is used to extend hour-by-hour instantaneous results to the entire day. Daily performance profiles are analyzed for N-and S- facing windows over a typical day in the heating season, Jan. 21, and in the cooling season, Jul. 21. Window applications, including daylighting, ultraviolet rejection, solar cooling load avoidance (summer) and solar heating (winter) are considered. Significant variations in window efficiency with window spectral selectivity, window orientation, type of ground reflection, and season are observed.

3202 Transportation

Refer also to citation(s) 6777, 7201

7821 (CONF-900121–1) **Estimating departure times from traffic counts using dynamic assignment.** Janson, B.N. (Oak Ridge National Lab., TN (USA)); Southworth, F. Oak Ridge National Lab., TN (USA). Jul 1989. 20p. Sponsored by Federal Highway Administration. DOE Contract AC05-84OR21400. From Transportation

Research Board meeting; Washington, DC (USA); Jan 1990. Order Number DE89016259. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A dynamic traffic assignment algorithm and observed traffic counts are used to estimate the distribution of departure times in a trip matrix. The objective is to find the maximum entropy distribution of departure times by origin zone subject to observed traffic counts on a subset of network links. The procedure results in the estimated number of trip departures from each origin in 10-15 minute time intervals of the full analysis period. Such an analysis period will typically range from one to three hours long. We first review the dynamic assignment algorithm developed and tested in a previous paper, and then describe its use with traffic counts to estimate the departure times of a trip matrix. We present an application to a Pittsburgh network in which trip departures are estimated for each 10-minute interval of a peak-hour survey trip matrix. Computational advances such as parallel computing will enable the procedure to be run on large networks while counts are being monitored. Such an application may provide near real-time detection of temporal trip departure profiles by origin zone. 19 refs., 1 fig., 2 tabs.

7822 (CONF-900121–2) **Dynamic traffic assignment for urban road networks.** Janson, B.N. (Oak Ridge National Lab., TN (USA)). Oak Ridge National Lab., TN (USA). Jul 1989. 27p. Sponsored by Federal Highway Administration. DOE Contract AC05-84OR21400. From Transportation Research Board meeting; Washington, DC (USA); Jan 1990. Order Number DE89016260. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This paper describes a dynamic traffic assignment (DTA) algorithm for urban road networks. The DTA algorithm is intended for application to large transportation planning networks with flow dependent travel costs and multiple origin and destination zones. The static user-equilibrium assignment problem (SUE) is a nonlinear programming problem with linear constraints that is typically solved by methods of linear combinations. The dynamic user-equilibrium assignment problem with multiple origins and destinations (DUE) is a nonlinear programming problem with nonlinear constraints that cannot be solved by these methods. Moreover, the constraints needed to ensure temporal flow continuity at the nodes cannot be properly specified within DUE. DTA is not a solution algorithm for DUE, but was designed instead to produce assignments that approximate the optimality conditions of DUE. Alternative approaches to dynamic assignment are discussed, including those that have been formulated as optimization problems and others that have been developed to simulate or approximate observed traffic conditions. Test results presented in this paper show that DTA generates both static and dynamic assignments that approximately satisfy the user-equilibrium conditions of those problems. 23 refs., 2 figs., 3 tabs.

7823 (CONF-900121–4) **Identical traffic streams in the TRAF-NETSIM simulation program.** Rathi, A.K. (Oak Ridge National Lab., TN (USA)); Santiago, A.J. Oak Ridge National Lab., TN (USA). Sep 1989. 25p. Sponsored by U.S. Department of Transportation. DOE Contract AC05-84OR21400. From Transportation Research Board meeting; Washington, DC (USA); Jan 1990. Order Number DE90001597. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This paper describes an enhancement to the TRAF-NETSIM simulation model. This enhancement provides users the ability to simulate with identical traffic streams through a series of runs. Thus, the user can make a series of simulation runs by retaining the traffic stream of an initial run while simulating under different traffic control or operational conditions in subsequent runs. The representation of stochastic behavior in the TRAF-NETSIM simulation model is described and the need for the generation of identical traffic streams is discussed. The two approaches considered in implementing this feature and the program modifications necessary to implement the selected approach are described. Some representative simulation results are presented and the applications and limitations of the identical traffic streams feature are discussed. 7 refs., 3 figs., 1 tab.

7824 (IEEJ–8901) **1989 National convention record I. E. E. Japan (Part 7).** Institute of Electrical Engineers of Japan, Tokyo (Japan). Apr 1989. 259p. (In Japanese). Order Number DE89910080. Available from NTIS (US Sales Only), PC A12/MF A01.

From presented articles of the National convention, I.E.E. Japan opened in April, 1989, the articles are recorded of the static machine, application of superconductivity and electric railway section, and the symposium Numerical analysis method of eddy current field and its verification model. The static machine section includes 79 articles: Simulation of hysteresis curves under the existence of air-gap, Calculation of magnetic field caused by circular ring coil and others. The application of superconductivity section includes 48 articles: Characteristics of superconducting synchronous generator, Design of nitrogen-cooled superconducting generator and others. The electric railway section includes 42 articles: Radio noises caused by railways, Prototype support system to decide renewal times for substation facilities and others. The symposium includes 6 articles: Three-dimensional eddy current field analysis by A-phi method, Three-dimensional eddy current field analysis by T-Omega method and others. 337 refs., 574 figs., 91 tabs.

7825 (NAL-SP–9, pp. 21-26) **Numerical simulations of the flow field in a SCRAM jet.** Hirai, Ken'ichi (Nissan Motor Co., Tokyo (Japan)). National Aerospace Lab., Chofu, Tokyo (Japan). Dec 1988. (In Japanese). In *Special publication of National Aerospace Laboratory. Proceedings at the 6th NAL symposium on aircraft computational aerodynamics.* Order Number DE89910195. Available from NTIS (US Sales Only), PC A12/MF A01.

In order to analyze the Supersonic Combustion Ram (SCRAM) jet engine in performance, the influence of non-reactive gas jet in the vicinity of fuel jetting position was studied on the flow field in combustion chamber. The SCRAM jet engine has the advantage, differentiating from the past engine, to unnecessitate the oxidant and be high in Isp. That engine is, to be materialized, problematic in held flame stability and self ignition property for the high and low flight Mach number zones, respectively. First, a two-dimensional compressive Navier-Stokes equation of one-compound or two-compound system was used as a governing equation. Next, a calculation, to grasp the influence of gas jet on the flow field in the vicinity of step, was made. As a result, the contribution of step to the compounding of air and hydrogen, in case of a large distance between the fuel jetting position and step, was small. Also the interference between the recirculation zones caused by the gas jet and that based on the existence of step was obtained. The above result gave a judgment for the influence of fuel jetting position to be large on the flame holding. 2 refs., 7 figs., 1 tab.

7826 (NAL-TR–998) **Metal combustion in solid-propellants.** Izumikawa, Muneo; Takahashi, Mamoru; Mitani, Toru; Niioka, Takashi; Chiba, Masatoshi; Kato, Kazushige. National Aerospace Lab., Chofu, Tokyo (Japan). Sep 1988. 35p. (In Japanese). Order Number DE89910189. Available from NTIS (US Sales Only), PC A03/MF A01.

An expedient, though accurate, to measure rocket propellant in combustion efficiency (eta) was studied. In high efficiency solid propellant, metal being utilized in high combustion heat, boron (B) was studied as fuel to replace aluminum (Al) in a certain propellant system. However as there are a few studies of high density metallic particle group, eta is presumed to be 100% or assumed through empirical rules. Therefore a combustion experiment being made, by using a burner, which was a past strand burner fitted with a surge tank filled with solvent, a method, to grasp, through solvent, combustion product of metallic fuel added to propellant, measure its degree in combustibility by the chemical analysis, expediently evaluate eta and extract parameters governing the degree in combustibility, could be developed. Its application quote, for example, the investigation of eta's dependency on pressure in Al and B, and eta in different kinds of propellant. A differential equation expressing the time change in metallic particle diameter distribution pattern was also quoted. 56 refs., 40 figs., 2 tabs.

7827 (NEI-DK–235) **Initiatives regarding new service principles in relation to public transport and energy conservation.** Energiministeriets forskningsprogram 1987. Energianvendelse i transportsektoren. Anders Nyvig A/S, Hoersholm (Denmark). Sep 1989. 185p. (In Danish). Contract EM-1243/87-8. Order Number DE90726107. Available from NTIS (US Sales Only), PC A09/MF A01.

EFP-87.

A former investigation in Denmark has shown that there are many buses on country routes or in small towns, and at special times of the day, who carry so few passenger that it can hardly pay to run them, especially when one considers the amount of energy consumed. Bus traffic in these areas has been investigated with the aim of discovering new ideas that could result in the service provided coinciding with the demand. It is suggested that routes and timetables should be adjusted in order to meet these demands and that it should be possible to order a bus by telephone or get hold of a taxi that could carry 8 passengers. Investigations, and suggestions for improvements of routes and the situations of busstops covering the whole of Denmark are described in detail and illustrated with maps and diagrams. (AB) 55 refs.

7826 (ORNL/TM–11278) **Estimating commercial truck VMT [vehicle miles of travel] of interstate motor carriers: Data evaluation.** Hu, P.S. (Oak Ridge National Lab., TN (USA)); Wright, T.; Miaou, Shaw-Pin; Beal, D.J.; Davis, S.C. Oak Ridge National Lab., TN (USA). Nov 1989. 96p. Sponsored by U.S. Department of Transportation. DOE Contract AC05-84OR21400. Order Number DE90004356. Available from NTIS, PC A08/MF A01 - OSTI.

This memorandum summarizes the evaluation results of six data sources in terms of their ability to estimate the number of commercial trucks operating in interstate commerce and their vehicle miles of travel (VMT) by carrier type and by state. The six data sources are: (1) Truck Inventory and Use Survey (TIUS) from the Bureau of the Census, (2) nationwide truck activity and commodity survey (NTACS) from the Bureau of the Census, (3) National Truck Trip Information Survey (NTTIS) from the University of Michigan Transportation Research Institute (UMTRI), (4) highway performance monitoring system (HPMS) from the Federal Highway Administration (FHWA), Department of Transportation, (5) state fuel tax reports from each individual state and the international fuel tax agreement (IFTA), and (6) International Registration Plan (IRP) of the American Association of Motor Vehicle Administrators (AAMVA). TIUS, NTACS, and NTTIS are designed to provide data on the physical and operational characteristics of the Nation's truck population (or sub-population); HPMS is implemented to collect information on the physical and usage characteristics of various highway systems; and state fuel tax reports and IRP are tax-oriented registrations. 16 figs., 13 tabs.

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Refer also to citation(s) 6754, 6756, 6807, 6820, 7053, 7682, 7714

7829 (AC/CB–1799/E) **Good energy management in farm livestock buildings.** Windfield, R.G.; Levesque, M. Agriculture Canada, Ottawa, ON (Canada). Communications Branch. 1986. 50p. (MICROLOG–89-03699). Available from PC Agriculture Canada, Communications Branch, Sir John Carling Bldg., Carling Ave., Ottawa, ON, CAN K1A 0C5; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

This publication points out inefficient energy uses and provides techniques or suggestions to reduce consumption in livestock buildings by making more efficient use of conventional energy (electricity, oil, liquified petroleum gas, or natural gas). Suggestions include improving system designs and/or managment, changing systems, or reusing energy that has been dumped. The publication covers heat balances in buildings, how environmental control is achieved, the energy cost of environmental control and the use of both existing and new technologies to reduce energy consumption. Such new technologies as heat pumps, heat exchangers, solar energy, biomass energy, wind energy, and geothermal energy are discussed. Tables summarizing the problem, the possible cause(s), and remedies for energy loss in summer and winter are also included. A glossary is given. 57 figs., 22 refs.

7830 (CANWEC–CE-02832, pp. 18) **The beneficial effects of energy savings on environment: Report 2.3.11. .** Alessandrini, A.; Billi, B.; Jemma, M.; Lanzuola, S. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02832). In *Energy for tomorrow. Division 2: Energy and the environment: Session 2.3: Environmental concerns: The role of technology.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The past few years has seen a growing awareness of the impact of human activity on the environment. Energy conservation will have a major impact in controlling atmospheric pollution. Some industrial activities, which are characterized as energy intensive, also determine a particularly important environmental impact. Energy savings projects in these industries, and in the activities of energy converion, can contribute in a significant way to reducing environmental degradation. In the last 15 years, many changes have taken place: the rise in the price of energy resources, the research on ecological damage, the diffusion of an environmental conscience, which have changed the economic aspects of the problem, and have re awakened public opinion. The main energy savings projects carried on in Italy in the steel, chemical and electrical power fields are described in detail from the energy conservation point of view. Important results have already been achieved. Other even greater results can be obtained for the furture, gradually as the development of technologies and the increase in awareness of the importance of the phenomenon encourage implementation. 2 figs.

7831 (CMRC–8901, pp. 285-292) **Effective and valuable utilization technology of fly ash in department of civil engineering.** Kanbe, Yoshio (The Coal Mining Research Centre, Japan, Tokyo, Japan); Igarashi, Kazuhiko; Momoi, Tetsuji. Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

As advanced utilization techniques of fly ash in a civil engineering field, following three techniques were proposed: (1) The technique to promote the hydration of fly ash by an accelerator, (2) The technique to stabilize reclaimed lands by the complex correlation between fly ash, reinforcement and basement, (3) The technique to use fly ash directly as cement by advanced works. As examples, two recent test results were presented. The high fly ash test embankment of 5m in height was constructed stabilizing its basement with cement and gypsum after covering the soft ground with water barrier sheets. As a result, the basement indicated an excellent stiffness and permeability resistance, and the settlement of the embankment was reduced to 60% compared with unstabilized one. On the RCC (roller compacted concrete) roadbed work, as 50 - 75% fly ash concrete was used instead of cement concrete, a very short construction period, very simple work and cost reduction by 30 - 40% were expected as compared with conventional concrete works. 18 figs., 1 tab.

7832 (CMRC–8902, pp. 128-140) **Underwater molding technology of artificial reef using fly ash.** Miwa, Tsugihisa (The Coal Mining Research Centre, Japan, Tokyo, Japan); Kazurayama, Fumiharu; Onoi, Yoshiki. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

By taking, as examples of subject, the mat reef corresponding to week soil seabed and large spouting type fish reef, as a series of coal fly ash utilization, the underwater molding technology was reported in result of study. For the effective utilization of coal fly ash in expectation, Electric Power Development has proceeded with development of utilization technology of it as hardened body, in which there is FGC concrete, mainly coal fly ash (F) mixed with gypsum (G) and cement (C), and then added with water to be as harden body. The mat reef corresponding to week soil seabed is a mat reef on bags installed on week soil seabed and filled with FGC slurry, while the large spouting type fish reef is a fish reef on cloth made Quonset hut shaped structure installed on seabed and filled with FGC slurry. For each of those reefs, after different laboratory tests were made, actual constructions on different sites were pursuit surveyed. As a result, FGC slurry in water weighs half as heavy as in air and is rich in fluidness, from which the construction method to use it is judged to be optimized for the artificial reef construction on week soil seabed. 2 refs., 16 figs., 8 tabs.

7833 (CMRC–8902, pp. 170-179) **Development of coal ashes utilization technique by hydrothermal reactions.** Ito, Hayami (Kawasaki Heavy Industries, Ltd., Tokyo, Japan); Maruyama, Tadashi; Shibata, Yasunori. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

Several kinds of hardened body by coal ash, different in chemical and physical properties, were reported in production method and quality prepared in a laboratory scale. Granular hardened body as upper road base material was also reported in result of actual road pavement test made in practical use scale. Kawasaki Heavy Industries proceeds with technological development, by using hydrothermal reaction technology, able to confront the change in chemical and physical properties of coal ash and easy in quality adjustment, to produce and utilize several kinds of hardened body. For the coal ash utilization, it is important to utilize the chemical and physical properties, confront the change in them and adopt the quality to the needs. For hardening coal ash, a method to add it with lime and gypsum, and that with sodium hydroxide were used. By using a granular hardened body production plant by the crushing method, granular hardened body was produced and tested as upper road base material, and evaluated, as a result, to be equally good to crushed stone in workability and adoptability, and sometime rather better than it in adoptability. 14 figs., 1 tab.

7834 (CONF-8911133–1) **Utilization of high-carbohydrate food wastes as the feedstock for degradable plastics.** Tsai, S.P.; Coleman, R.D.; Tsai, TenLin S.; Bonsignore, P.V. Argonne National Lab., IL (USA). [1989]. 10p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract W-31109-ENG-38. From Food processing waste conference; Atlanta, GA (USA); 6-8 Nov 1989. Order Number DE90003572. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Wastestreams from food processing industries have become an economic burden as well as a serious environmental problem. In the United States, billions of pounds of potato processed each year is typically discarded or sold as cattle feed at $3-6/ton. For large food processing plants, removal of more than 1 million gallons of waste/day/plant is required. As a potential solution to this economic and environmental problem, Argonne National Laboratory is developing technology that (1) bioconverts existing food processing wastestream into lactic acid, and (2) utilizes lactic acid for making environmentally safe, degradable plastics. Although the initial substrate for Argonne's process development is potato waste, the process will be applied to many other high-carbohydrate food wastes. Argonne has developed a process to bioconvert greater than 90% of the fermentable starch in solid potato waste to glucose. Lactic acid is produced from glucose via fermentation and subsequently recovered/purified for plastic synthesis. A continuous lactic acid fermentation and recovery process has been designed. Batch fermentation data showed good cell growth and excellent yields (greater than 95%) of lactic acid production from the hydrolyzed potato waste. Three product recovery processes (electrodialysis, liquid-liquid extraction, and esterification) are being evaluated. Plastics containing lactic acid can be designed to have various mechanical properties and degradation rates. Argonne is developing lactic acid plastics that have some novel features. These environmentally-safe, degradable plastics have many attractive applications such as composting bags and agriculture mulch films. Other potential applications of lactic acid polymers include programmable pesticide and fertilizer delivery systems.

7835 (DOE/CE/40699–T11) **Energy conserved and costs saved by small and medium-size manufacturers: 1986–87 EADC [Energy Analysis and Diagnostic Center] program period.** Kirsch, F.W. University City Science Center, Philadelphia, PA (USA). Industrial Technology and Energy Management Div. Mar 1989. 37p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract FC01-84CE40699. Order Number DE90003455. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The Energy Analysis and Diagnostic Center (EADC) program provided energy-conserving and cost-saving assistance in 324 small and medium-size manufacturing plants during its 1986–87 operating period. This report presents the results produced by 13 EADCs which performed those 324 energy audits nationwide and then obtained additional data during 1988 from 322 manufacturers who had implemented at least some of the EADCs' recommendations or definitely scheduled implementation within two years.

7836 (DOE/CE/40738–T4) **High-intensity drying processes: Impulse drying: Yearly report.** Orloff, D.I. Institute of Paper Science and Technology, Atlanta, GA (USA). May 1989. 46p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract FG02-85CE40738. Order Number DE90002900. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Impulse drying is an innovative process for drying paper that holds great promise for reducing the energy consumed during manufacture of paper and similar web products. Impulse drying occurs when a wet paper web passes through a press nip where one of the rolls is heated to a very high temperature. Steam generated by contact with the hot roll expands and displaces water from the sheet in a very efficient manner. The energy required for water removal is much lower than that required for conventional evaporative drying. Tests have been completed that elucidate the unique displacement mechanism of water removal in the impulse drying process. A pilot roll press has been designed, installed and used to examine impulse drying under conditions that simulate commercial press conditions. The results of this earlier work have been reported in three previous reports. During this report period October, 1987 to September, 1988, the pilot press was equipped with a second impulse drying roll to facilitate studies of surface uniformity in impulse dried paper. Studies have also been completed which examine the origins of sheet delamination that has been been encountered during impulse drying of certain heavyweight paper grades, and which investigate approaches to prevent delamination in these grades. Finally, an experimental plan has been formalized to examine impulse drying of lightweight grades which are candidates for early commercialization. 7 refs., 30 figs., 3 tabs.

7837 (NEI-DK–237) **Investigation of cooling systems: Partial report 1.** Martens, P. Teknologisk Inst., Taastrup (Denmark). Afd. for Varme-og Installationsteknik. Aug 1989. 124p. (In Danish). Contract EM-1223/87-7. Order Number DE90728130. Available from NTIS (US Sales Only), PC A06/MF A01.

EFP-87.

The aim was to test and compare various forms of computerized control systems in relation to larger refrigerators utilized in supermarkets in order to improve energy efficiency, and also standards of maintenance, monitoring, operation and service life. It is expected that advanced computerized control systems could reduce electric power consumption by 50%. They could be available to the Danish market in 1993-1995. (AB).

7838 (NEI-DK–238) **Investigation of cooling systems: Partial report 2.** Martens, P. Teknologisk Inst., Taastrup (Denmark). Afd. for Varme-og Installationsteknik. Aug 1989. 86p. (In Danish). Contract EM-1223/87-7. Order Number DE90728131. Available from NTIS (US Sales Only), PC A05/MF A01.

EFP-87.

The aim was to test and compare various forms of computerized control systems in relation to larger refrigerators utilized in supermarkets etc. in order to promote energy conservation, improve efficiency and also standards of maintenance, monitoring, operation and service life. The performance tests were analysed and interpreted, ways of utilizing the results were examined and a basis for training of personel initiated. (AB).

7839 (SJF-Beretning–43) **Potential for saving by utilizing time-of-use pricing of electric power used in farming.** Guul-Simonsen, F.; Kofod, C. Statens Jordbrugstekniske Forsoeg, Horsens (Denmark). 1989. 61p. (In Danish). Contract EM-1233/86-2. Order Number DE90728155. Available from NTIS (US Sales Only), PC A04/MF A01.

EFP-86.

The aim was to investigate possibilities for energy saving within the field of agriculture by shifting energy consumption to nights and weekends. It is estimated that this would decrease overall costs of electric power consumed in relation to farming by 19%. The new structure of farming in Denmark, which aims at reducing the number

of farms so that the production of the individual unit will increase, will encourage a further decrease of electricity consumption. Research is related to the utilization of computerized control (Load Management System). Investment in steering automats and low energy equipment, in addition to advisory services would be necessary. The repayment period is estimated to be 3-7 years. Electric power consuming activities which could be shifted to night periods are cereal grinding, production and handling of feed, water pumping, stirring of slurry, accumulation of electric heat, field irrigation and grain drying. Electricity consumption could also be reduced if more efficient ventilating and lighting systems, drying plants and pumps were used. It is reconed that if Danish farmers adapt to the time-differentiated tariffs, especially the triple tariff (3 different prices on a 24-hour basis) an average saving of 10-30% on electric power consumption is possible. (AB) 35 refs.

7840 (STU–87-1790) **Small scale cogeneration with heat production for drying processes.** Eklund, L.G. (Statens Provningsanstalt, Boraas (Sweden)); Karlsson, M.L. Swedish National Board for Technical Development, Stockholm (Sweden). 30 Jan 1989. 126p. (In Swedish). Project STU-742-87-01790. Order Number DE90728277. Available from NTIS (US Sales Only), PC A07/MF A01.

A survey of dryers employed in swedish industry, except cellulose- and paper industry, is presented. Answers to a questionnaire are reviewed branchwise, with information on performance and oerating conditions. A literature study on installations for, and experiences of, small scale cogeneration units in drying processes is also accounted for. A few small cogeneration systems are outlined, specially for drying processes of sawing mills and sugar industries, using a fuel mix of natural gas and solid fuels. Furnace processes are illustrated through a gas turbine cogeneration system coupled to lime kiln at a cellulose plant. 87 refs.

7841 (STU–87-3352) **Energy conservation in electric furnaces: A preliminary study.** Rensgard, A. (MEFOS, Luleaa (SE)). Swedish National Board for Technical Development, Stockholm (Sweden). 24 Feb 1989. 42p. (In Swedish). Project STU-742-87-3352. Order Number DE90728278. Available from NTIS (US Sales Only), PC A03/MF A01.

First, a short review of earlier projetcs on energy use in electric furnaces in steel industry is given. Then, the most common heat treatment processes and furnaces are described. Some Swedish steel industries electric furnaces have been studied closely, their energy consumption measured and their data compiled.

7842 (STU–88-2837) **Impulse drying of paper: Literature survey and evaluation of different heat supplying alternatives.** Stenstroem, S. (Kemisk apparatteknik, Lund (SE)). Swedish National Board for Technical Development, Stockholm (Sweden). Feb 1989. 88p. (In Swedish). Order Number DE90728332. Available from NTIS (US Sales Only), PC A05/MF A01.

The principle of the process is to subject the web to high pressures in contact with a very hot cylinder surface for a very short period. The high temperatures result in a quick supplying of heat and a substantial increase of the steam pressure in the sheet. The drying process becomes very quick at the same time as some of the water is forced out of the sheet in liquid state. In this way a part of the water does not need to be evaporated. The specific energy consumption will be low. Figures below half of the vaporization heat have been recorded. The number of drying cylinders could probably be considerably reduced. 73 figs., 9 tabs., 53 refs.

7843 (VTT-SYMP–102) **Non-waste technology: Volume 1.** Korhonen, M. (ed.). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. 443p. (CONF-8806445–Vol.1: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). Order Number DE90728202. Available from NTIS (US Sales Only), PC A19/MF A01.

The VTT Symposium on Non-Waste Technology was held in Espoo, Finland, on June 20-23, 1988. The Symposium was organized within the framework of a three-year research programme on Non-Waste Technology carried out at the Technical Research Centre of Finland in 1986-1988 in the hope of enhancing the interaction between scientists working in different fields of technology, and of discussing new possibilities to overcome the difficulties we are facing today and can foresee for tomorrow. The programme consisted of sessions addressing questions of a more general concern and of a series of more detailed technical sessions on Resource Management, Novel Process Technology, Industrial Implementation of Non-waste Technologies, and Waste Reduction and Pollution Control. The Proceedings cover the technical part of the conference. Poster presentations and workshops were also held to provide a forum for discussions on specific research or industrial activities as well as on the situation in the developing countries.

7844 (VTT-SYMP–102, pp. 89-102) **Non-waste technology in agriculture: microeconomic aspects of the biomass refinery.** Petersen, B. (Carlsberg Research Laboratory, Copenhagen (Denmark). Department of Biotechnology); Andreasen, L. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

As imbalance problems in European agriculture have become more pronounced the need for new industrial outlets for agricultural raw materials is increasing. One approach to increased industrial use of agricultural raw materials is a non-waste - or whole crop - utilization of the plant. Similar to the refineries in the petrochemical industry, which enables full utilization of the hydrocarbon raw materials by separation into a wide range of products, biomass refineries should be introduced in the agricultural areas in order to exploit each component of the agricultural whole crop in accordance to its physical properties. A way to ensure better utilization of field machinery as well as the biorefinery capacity is to stretch out the plant season by inclusion a broad range of new and traditional crops. Altogether these measures should minimize investment costs, i.e. fixed costs per unit, sufficiently to secure a profitable, non-waste production. In particular as regards value-added utilization of agricultural by-products, the biorefinery concept seems promising. This in contrast to e.g. straw for heating purposes. Straw burners have become widely used in Denmark, but only through heavy subsidizing. On the island of Bornholm in the Danish part of the Baltic Sea, experiments have been carried out in connection to a large dehydration plant. The first commercial biorefinery commenced its activities in the summer 1988 after rebuilding of the plant. The economic calculations presented here are to some extent based on the experiences obtained from Bornholm.

7845 (VTT-SYMP–102, pp. 227-245) **Mapps modeling and design of a black liquor fluidized bed dryer.** Sell, N.J. (University of Wisconsin-Green Bay, Green Bay (USA)); Clay, D.T. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

The solids content of concentrated black liquor is a critical parameter in the design and operation of a kraft recovery boiler. The trend today is to go to higher solids content in order to increase the effective capacity of the boiler and potentially improve its performance. A fluidized bed dryer patented by the Institute of Paper Chemistry (IPC) is one process which recently has been shown in laboratory tests to be capable of attaining 95% solids. This paper describes the mathematical modeling of a fluidized bed dryer using the IPC MAPPS (Modular Analysis of Pulp and Paper Systems) computer program. MAPPS was originally designed for the calculation of mass and energy flows, but its overall structure makes it ideal also for equipment design. Summarized are the resulting design parameters for a 200 ADTPD unit.

7846 (VTT-SYMP–102, pp. 399-408) **Acetosolv-pulpint and bleaching.** Ninz, H.H. (Federal Research Center for Forestry and Forest Products, Hamburg (Germany, F.R.) Institute of Wood Chemistry and Chemical Technology of Wood); Berg, A.; Granzow, C.; Casen, R. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

Acetosolv-pulping uses 93% aqueous acetic acid in the presence of 0.1-0.2% hydrogen chloride as a cooking liquor at 110 deg C. After a 3-5 h cooking time the defiberized wood chips are extracted with hot acetic acid. Kappa numbers around 20 are obtained for spruce and pine woods, and around 15 for hard-woods. Even lower kappa numbers may be obtained by counter-current extraction. Bleaching with ozone in acetic acid is more selective than in aqueous systems, due to a higher solubility of ozone, reduced formation of OH radicals and higher solubility of lignin degradation products. Hydrogen peroxide, due to its reaction with acetic acid to peracetic acid, is also a very powerful and selective bleaching agent. The combination of ozone with hydrogen peroxide offers an alternative for bleaching acetosolv-puls under economic conditions, producing no waste materials in a counter-current extraction proceduce. Another advantage is the isolation of sulphur-free lignin and hemicellulosees, which have not to be burnt for the recovery of inorganic pulping chemicals.

7847 (VTT-SYMP–102, pp. 391-398) **Prerequisites of non-waste pulping.** Palenius, P. (Keskuslaboratorio, Helsinki (Finland)). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

Sulphate pulping, chemi-mechanical pulping, thermomechanical pulping and groundwood pulping are compared in terms of wood consumption, energy requirement, chemicals consumption and final effluent. Although wood consumption is low and chemicals consumption negligible in mechanical pulping, the energy required has to be obtained from outside. In chemi-mechanical pulping consumption of chemicals is reasonable but the energy requirement is high. On the other hand, the effluent load can be controlled by external treatment. The sulphate process actually generates energy, as it uses over half the raw material for this purpose; the problem is the chlorine chemicals used to bleach the pulp. Non-waste pulping is impossible as long as chlorine chemicals are needed for bleaching.

7848 (VTT-SYMP–102, pp. 377-388) **The polyad fb process for voc control and solvent recovery.** Heinegaard, C. (Nobel Chematur AB, Karlskoga (Sweden)). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

Polyad is a collective name, which we use for air and water purification processes based on macroporous polymer particles as adsorbents. The adsorbents have been developed by Nobel Chemicals and the processes by Nobel Chematur. Both of these companies are divisions fo Nobel Industries, the major chemicals corporation in Sweden. Polyad FB is a continuous adsorption process based on fluidized bed technology. After successful development work Nobel Chematur is now introducing this process on the market and several new plants will be started up in Sweden this year. The heart of the Polyad process is the unique adsorbent called Bonopore. It consists of macroporous polymer particles having properties being superior to existing adsorbents, such as activated carbon, regarding low energy requirement for regeneration, high quality of recovered solvents and ability to perform well at very high humidity in the air to be treated. Before going into details about the Polyad FB process the development and unique properties of the polymer adsorbent will be discussed.

7849 (VTT-SYMP–102, pp. 367-376) **Adsorptive removal and recovery of organic solvents.** Henning, K.-D. (Bergwerksverband GmbH, Essen (Germany, F.R.)); Bongartz, W.; Degel, J. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

Organic solvents are used in numerous industrial processes and are often released into the atmosphere through the waste air. For waste air purification and solvent recovery adsorption processes have been successfully applied for many years, the adsorbent activated carbon has proven its technical value. The physico-chemical fundamentals of adsorption processes are explained. The construction type and technical design of activated carbon adsorbers for solvent recovery are described. Operating results of plants for the recovery of toluene and trichlorofluoromethane illustrate the technical and economic advantages of adsorption processes.

7850 (VTT-SYMP–102, pp. 329-344) **Recovery of nickel by crystallization of nickel carbon in a fluidized-bed reactor.** Wilms, D. (Catholic University of Leuven, Leuven (Belgium)); Rai, P.B.; Dijk, J. van; Schoeller, M. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

The paper deals with the crystallization of nickel carbonate. With the help of a laboratory-scale reactor and by using pure solutions of nickel sulphate, optimal conditions for a number of parameters have been studied at the University of Leuven. At present, DHV is working with real baths in full-scale pellet reactors.

7851 (VTT-SYMP–102, pp. 421-434) **Pretreatment with no NO_2 of kraft pulp before oxygen bleaching.** Samuelsson, O. (Chalmers University of Technology, Gothenburg (Sweden) Department of Engineering Chemistry); Oejteg, U. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

Conventional oxygen bleaching following pretreatment with nitrogen oxides in a new process denoted S3 permits reduction of the lignin content (kappa number) by 90% without severe depolymerization of cellulosee, Fully bleached pulp with a brightness of 90 according to ISO can be produced in a final three-stage sequence without any addition of elementary chlorine. Chlorine dioxide is used in so small amounts that it should be possible to recover and burn the organic products in the spent liquors together with the black liquor. The S3 process was applied under following conditions: 1. Treatment with 2% NO_2 at 12% consistency and 40 deg C for 15 min. 2. Dilution with acid sodium nitrate solution (simulating spent pretreatment liquor) to 5% consistency. 3. Ripening at high temperature (90-105 deg C) for 180 min.

7852 (VTT-SYMP–102, pp. 409-420) **Improved utilization of black liquor through liquid-phase thermal processing.** McKeough, P. (Valtion Teknillinen Tutkimuskeskus, Espoo (Finland) Polttoaine- ja jalostustekniikan Lab); Alen, R.; Oasmaa, A.; Johansson, A. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

Liquid-phase thermal processing of kraft black liquor opens the way for improved utilization of the organic material of the liquor. When the treatment is carried out under reducing conditions, an oil-like organic-phase product is formed. This process concept was studied in a series of experiments in which pine kraft black liquor was thermally treated under different reactant atmospheres. In each case, the macroreactions of the black liquor organic material were elucidated. The experimental data was also used as the basis of an economic evaluation of the application of the technology in projects aimed at increasing the recovery capacity of existing mills. Encouraging results were obtained.

7853 (VTT-SYMP–102, pp. 447-457) **Anaerobic digestion of lime-straw pulping waste liquor to reduce pollution.** Wu Qiang, (Beijing Institute of Light Industry, Beijing (China)); Shi Jiapei,; Zhang Ke,; Lan Sheyi,. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

Feasibility and basic factors of anaerobic digestion for lime-straw pulping waste liquor to reduce pollution were studied using 5-litre laboratory intermittent make-up digesters. Further, 16-litre and 100-litre uniquely designed continuous-operating digesters were operated under conditions of make-up CODcr concentration around 12 000 mg/l, hydraulic retention time 1.1-1.2 d, digesting temperature 38 to 40 deg C. The CODcr volumetric load, the CODcr reduction and biogas production reached 10 to 12 g/l . d, over 80%, and over 0.45 l/g CODcr (removed) (CH_4 over 65% v/v), respectively. The fundamental factors influencing the digesting process and efficiency are discussed.

7854 (VTT-SYMP–102, pp. 435-446) **External reduction of aox in bleached pulp effluents.** Ek, M. (STFL, Stockholm (Sweden)); Eriksson, K.E. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

The release of organically bound chlorine (measured as TOCl or AOX) in bleached pulp effluents will have to be reduced to minimize the risk of negative effects on the environment. This will most likely be accomplished by a combination of internal measures, such as continued modifications of the cooking and bleaching processes and external effluent treatments. Existing biological methods for effluent treatment were developed mainly to reduce the amount of BOD and are not very effective in reducing AOX. A combination of ultrafiltration and biological processes has been tested. Small-scale experiments have indicated that such a combined treatment can give 95% reduction of BOD and 70-90% reduction of COD and AOX. At the same time the colour of the effluent is reduced by about 50% and the acute toxicity is almost completely eliminated. Thanks to a fast biological system the total cost for the combined treatment will not be higher than that for an aerated lagoon, where the reduction of AOX is normally not more than 25-30%. Results from laboratory and small pilot plant tests in a factory are presented in this paper.

7855 **Industrial complexing and ferrate treatment for reuse of wastewaters of small textile mills.** Nemerow, N.L. (College of Engineering, Univ. of Miami, Coral Gables, FL (US)); Waite, T.D. vp of The 8th Miami international conference on alternative energy sources. Volume 1-2 (Condensed Papers). Vezioglu, T.N. Clean Energy Research Inst. University of Miami, Coral Gables, FL (1988). (CONF-871204–: 8. Miami international conference on alternative energy sources, Miami Beach, FL (USA), 14-16 Dec 1987).

Small textile mills face unique situations when encountering both environmental and production problems. Environmental problems arise because conventional wastewater disposal is usually too expensive to allow costs to be passed on to the consumer. Production problems center mostly about the relatively high unit cost manufacturing in worldwide competition with larger-sized mill. Both problems result partly from the absence of adequate, low cost process water. Lower production costs and elimination of adverse environmental impacts can be achieved by wastewater reuse, replacing some need for imported process water. In this paper, the authors propose two methods for accomplishing effective wastewater reuse. The first, industrial complexing, involves combining the small textile finishing mill with other related manufacturing plants which allow direct consumption of all wastes as raw materials. The second, ferrate treatment, utilizes higher positive ion charges of iron to effect extremely efficient coagulation of certain segregated textile mill wastewaters.

3206 Municipalities and Community Systems

Refer also to citation(s) 7203, 7518, 7609, 8182, 8377

7856 (CANWEC–CE-02832, pp. 15) **The positive effect of district heating on the environment: Report 2.3.6. .** Stalebrant, R.E. (Swedish District Heating Association (Sweden)); Almqvist, P.; Lindrjo, L.; Olofsson, L.; Westergard, B. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02832). In *Energy for tomorrow. Division 2: Energy and the environment: Session 2.3: Environmental concerns: The role of technology.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The advantages of the district heating production units and distribution systems over other heating methods with respect to efficiency, cost flexibility of fuel supply, possibility of cogeneration and environment are described. Reasons are given why expansion of district heating networks will reduce pollution. Several cities in Sweden were surveyed for the emission and concentration of sulphur and nitrogen, the results can be useful for other countries in a similar situation. Computer models were developed to allow calculation of pollution concentrations for future alternative heating supply systems in cities. Pollution with sulphur and nitrogen from Swedish sources could achieve ecologically acceptable low level, but when non-Swedish sources are added, pollution still represents a problem in many parts of Sweden. The soil and many lakes are now acidified and the growth rate of the forests, a vital factor in the national economy is threatened. It is concluded that as a result of increasing concern for the environment, high pollution levels from big plants are no longer acceptable. Techniques to reduce pollutants are discussed.

7857 (CPS–40-11/14-1989E, pp. 2A15-2A34) **Comprehensive waste management strategies incorporating incineration.** Palombella, R.F. (Pal-Tech Engineering Inc., Hamilton, ON (Canada)); Kennedy, J.W. Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

In a recent initiative, the Region of Hamilton-Wentworth (Ontario) has commissioned the development of new strategies to maximize municipal waste incineration with energy recovery and materials reclamation, while minimizing landfilling requirements. These staged strategies will reduce the landfill demand at the Region's disposal site from 250,000 to about 66,000 tons/y. The strategy includes improved waste stream control measures, recovery of substantial amounts of wood and corrugated cardboard, and a simplified fuel preparation process for upgrading refuse. The new strategies can be implemented directly and easily, without major changes in the refuse collection system. 5 figs., 2 tabs.

7858 (CPS–40-11/14-1989E, pp. 2A1-2A14) **RDF [Refuse derived fuel] processing plant maintenance management.** Morgan, W. T. (Sandwell Swan Wooster Inc., Atlanta, GA (USA)). Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

A review is presented of articles primarily from the pulp and paper industry which illustrate maintenance management organization, work orders, training, preventive maintenance, and contract maintenance. Discussion focuses on the application of maintenance management to plants that process refuse-derived fuels. Such plants are like pulp and paper plants in that they both utilize a series of unit processes. However, while the production side of these plants has received ample attention, maintenance has not, in spite of its importance in keeping the refuse-derived fuel plant operating reliably and productively. The maintenance management improvements proposed in this paper have the overall objective of

structuring the plant organization to optimize the maintenance capability. It is felt that if the trends in the pulp and paper industry are any indication, the cost of refuse-derived fuel plant maintenance can be held steady even with increased production, when modern maintenance management is implemented. 10 refs., 2 figs., 1 tab.

7859 (CPS–40-11/14-1989E, pp. 2A35-2A59) **Resource recovery in Palm Beach.** Keith, T.R. (Solid Waste Authority of Palm Beach County, West Palm Beach, FL (USA)); Bielawski, G.T.; Majur, K.S.; Herrmann, R. Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

A third-generation resource recovery facility is being installed in Palm Beach, Florida in order to handle the region's growing production of solid waste. The facility will process 2000 tons of municipal solid waste per day and consists of a refuse-derived fuel plant, a boiler plant, and an electrical generating plant. The noncombustible material in the waste is separated, and metals are recovered. From every 100 tons of waste, the plant is expected to recover about 5 tons of ferrous metal and 1 ton of aluminum, and to process about 83 tons of refuse-derived fuel. Net electric output of the facility is estimated at 563 kWh/ton of reference waste. Descriptions are provided of the design of various plant components and systems, including infeed and size reduction systems, separation equipment, boiler technology, ash handling and air quality control, steam turbines, water systems, and power generation facilities. 9 figs., 1 tab.

7860 (CPS–40-11/14-1989E, pp. 4B1-4B10) **Laboratory pilot scale evaluation of lead recovery from municipal solid waste incinerator ash.** Legiec, I.A. (State Univ. of New Jersey, Piscataway, NJ (USA)); Hayes, C.A.; Kosson, D.S. Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

High levels of potentially leachable toxic metals such as Pb, Cd, and Cr in ash residues of municipal solid waste incinerators require consideration of treatment technologies prior to disposal or utilization of the ashes in other applications. Extraction studies revealed information on the leaching characteristics of the ashes and on the ability of the extraction solutions to separate these metals from the ash matrix. The kinetics of the Pb, Cd, and Cr extraction were determined through a series of batch extraction studies. The specific incinerator design and the equilibrium conditions strongly influenced the ash matrix and subsequently the extraction kinetics. Recovery of the metals from the waste extract solution was accomplished utilizing electrochemical plating techniques. A laboratory scale pilot plant was designed to treat ash residues continuously at a rate of 1 kg/h through extraction and electrochemical techniques. Initial pilot plant operational study results are presented. Total metals analyses performed on the treated and untreated ashes reveal a 45% reduction for Pb and a 90% reduction for Cd. 6 refs., 5 figs., 2 tabs.

7861 (KFK–4600) **A knowledge acquisition facility for a knowledge-based system on risk assessment of contaminated sites.** Clausen, U. Kernforschungszentrum Karlsruhe G.m.b.H. (Germany, F.R.). Inst. fuer Datenverarbeitung in der Technik; Kernforschungszentrum Karlsruhe G.m.b.H. (Germany, F.R.). Projekt Schadstoffbeherrschung in der Umwelt (PSU). Aug 1989. 74p. (In German). Order Number DE90729010. Available from NTIS (US Sales Only), PC A04/MF A01.

Three categories of knowledge acquisition are explained. Expertise in 'Risk assessment of hazardous waste sites' and a prototype of the system XUMA (Expert system environmental hazard of contaminated sites) are analysed from the knowledge acquisition point of view. The differences between established architectures for heuristic classification and the architecture of XUMA are considered. Based on regularities in the prototype's knowledge base an application-dependent knowledge acquisition facility is designed. The structure for knowledge entry or modification by menu-oriented methods is based on objects on the three levels rules, forms within rules and groups of rules. The knowledge can be represented in terms familiar to domain experts. The concept of rule groups provides an access heterarchy and thus supports structuring the knowledge base. The system was implemented in Common Lisp and the Flavor-System on a TI Explorer II. (orig.) With 46 refs.

7862 (OE–CE-02818) **Municipal recycling support program. Guide to applicants.** Ontario Ministry of the Environment, Toronto, ON (Canada). [1989]. 18p. (CE–02818). Available from Publications Ontario, 880 Bay St., 5th Floor, Toronto, ON, CAN M7A 1N8. Prices: N/C.

The Municipal Recycling Support Program stems from the Ontario Ministry of the Environment's policies and programs begun in 1980 aimed at encouraging the development of source separation projects in Ontario. To qualify for financial assistance, municipalities must play a central role in the implementation and ongoing development of recycling; applications will be supported only if there is adequate and reasonable commitment from markets for recovered materials; recycling systems must operate within the framework of a complete waste management system in which cost effectiveness is an important factor; multi-material projects are encouraged as much as possible; and the Ministry will share the costs of projects with the municipalities. The Ministry provides grants for up to 5 years per project to cover the net operating cost of a project up to a specified maximum percentage of eligible gross operating expenses. This manual provides guidelines for applying for such funding, including definitions of eligibility for operating and capital costs, the use of household bins, and guidelines for promotion and advertising, education, demonstration, and feasibility studies.

7863 (ORNL/TM–11100) **Ranking of Air Force heating plants relative to the economic benefit of coal utilization.** Griffin, F.P.; Thomas, J.F.; Holcomb, R.S.; Young, J.M. Oak Ridge National Lab., TN (USA). Nov 1989. 233p. Sponsored by U.S. Department of Defense. DOE Contract AC05-84OR21400. Order Number DE90004350. Available from NTIS, PC A11/MF A01 - OSTI; GPO Dep.

The Defense appropriations Act of 1986 requires the Department of Defense to use an additional 1.6 million tons of coal per year at their US facilities by 1995. It also states that the most economical fuel should be used at each facility. To comply with this act, the United States Air Force requested Oak Ridge National Laboratory to evaluate the feasibility and economics of using coal at Air Force heating plants that currently burn natural gas and/or oil. A life-cycle cost analysis of 16 heating plants was performed, and the results were used to rank the facilities from best to worst according to their potential for economical utilization of coal. As many as 12 different coal combustion technologies were analyzed at each Air Force site. Also, two years of financing and three levels of fuel escalation were examined in the analysis for a total of six economic scenarios. The heating plants at Arnold, Kelly, Grand Forks, Minot, Robins, Plattsburgh, and McGuire Air Force bases were consistently identified as the top seven facilities for coal conversion, but the actual amount of cost savings will be strongly dependent on future fuel escalation rates. 10 refs., 3 figs., 22 tabs.

7864 (SV-UL–89-21) **Medium-sized rock heat source systems: Dimensioning analyses.** Spante, L. Swedish State Power Board, Aelvkarleby (Sweden). 24 May 1989. 40p. (In Swedish). Order Number DE90728299. Available from NTIS (US Sales Only), PC A03/MF A01.

Results from these medium-sized rock heat source systems show that more functional trouble and inferior performance than expected

are obtained if the borehole system is not adapted to the temperature demands of the heat pump cold transfer fluid. The design of the evaporator causes the evaporation temperature to become to low when the cold transfer fluid temperature reaches its lowest level for the year in two of the three plants studied. The third plant presents no functional trouble despite being operated at the same lowest cold transfer fluid temperature during the first years of operation. An analysis of complementary addition of boreholes in one of the plants with functional trouble reveals that the solution may be interesting if the heat pumps has to be capacity controlled for long periods during the heating season. In that plant the space for additional boreholes is limited, why the cost of this measure might be higher than the estimated SEK 240 per meter borehole. The computer code SBMA shows good agreement with measured weekly notations of the cold transfer fluid temperature during the first years of operation. The long-term temperature reduction caused by interaction between the closely located boreholes cannot be verified from only three years of operation. This fact gives cause for a follow-up of a number of medium-sized rock heat source systems for some additional years. 13 illus., 16 tabs. (author).

7865 (VTT-TIED–1021) **Combustion of westes in hospitals.** Puustinen, H. (Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). LVI-tekniikan Laboratorio); Hahkala, M.; Laukkarinen, A. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). Jul 1989. 48p. (In Finnish). Order Number DE90728186. Available from NTIS (US Sales Only), PC A03/MF A01.

This report deals with combustion technique of hospital wastes and flue gases and technical possibilities for improving combustion process and for decreasing emissions.

3209 Education and Public Relations

Refer also to citation(s) 7208

7866 (LA-UR–86-2600, pp. 66-71) **Caribbean basin proyecto.** Hanold, R.J.; Loose, V.W. Los Alamos National Lab., NM (USA). Fal 1986. In *Los Alamos science, Number 14*. Order Number DE87003612. Available from NTIS, PC A06/MF A01.

The rim of stability sought by President Reagan depends on energy and economic independence in Central America and the Caribbean Islands. These regions are rich in energy and mineral resources but the local populations need help to develop them. Los Alamos is setting a precedent by providing that aid through direct contact, training, and research and development in the host countries.

33 ADVANCED PROPULSION SYSTEMS

3301 Internal Combustion Engines

Refer also to citation(s) 7824, 7871, 7878

7867 (BI/RDPD–TP8395E) **Bombardier single-cylinder medium-speed research engine and test facility. Phase 3: Qualification.** Payne, M.L. (Bombardier Inc., Montreal, PQ (Canada)). Bombardier, Inc., Montreal, PQ (Canada). Rail and Diesel Product Div. May 1987. 117p. (MICROLOG–89-04067). Available from PC Transportation Development Centre (Canada), Complexe Guy-Favreau, 2000 Rene-Levesque Blvd. West, West Tower, Suite 601, Montreal, PQ, CAN H2Z 1Z4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

In recognition of the need for continuing improvement in the reliability and efficiency of medium-speed diesel engines, Bombardier began in the late seventies to concentrate its efforts on improving the performance characteristics of its Model 251 diesel engines. After a search for, and assessment of, available research engines, the Bombardier single-cylinder research engine (BSCRE) program was proposed, leading to an operational BSCRE facility. This report covers work done in the third phase of the program. One of the tasks addressed was the purchase and installation of an independent charge air supply compressor and a computer data acquisition system, thereby completing the required support equipment. Engine qualification studies consisted of a series of tests to verify the performance of the various engine components/systems under normal and abnormal operating conditions. Performance maps and power assembly temperatures were taken. In addition, friction horsepower values were measured and compared to the multi-cylinder engines. In single vs multi-cylinder fuels correlations, 3 activities were carried out: design and installation of a fuel supply and blending system; building of a fuels and lubricants analysis laboratory; and correlation tests of alternative fuels previously done on a multi-cylinder engine. The BSCREs are engine derivatives of turbocharged engine families. To understand the influence of turbocharger characteristics and performance relative to engine performance, a separate test rig was designed, and some of the major components were manufactured. The tasks performed in this phase of the BSCRE program have successfully brought the engines and test facility to operational status. 3 refs., 45 figs., 1 tab.

7868 (BI/RDPD–TP9022E) **Dual-fuel locomotive program: Program definition and preliminary investigation.** Payne, M.L. (Bombardier Inc., Montreal, PQ (Canada)). Bombardier, Inc., Montreal, PQ (Canada). Rail and Diesel Product Div. Sep 1988. 102p. (MICROLOG–89-04040). Available from PC Transportation Development Centre (Canada), Complexe Guy-Favreau, 2000 Rene-Levesque Blvd. West, West Tower, Suite 601, Montreal, PQ, CAN H2Z 1Z4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

This report identifies and outlines the technical parameters and activities foreseen as pertinent to the successful demonstration of a Canadian mainline locomotive using natural gas as the main fuel. This document also serves as the preliminary study of the dual-fuel locomotive program. The main elements of work identified are: technological literature search and review; dual-fuel conversion package design for the Bombardier model 251 diesel engine using current technology; locomotive modification designs; fuel tender parameters; and the conceptual design of the power-set (locomotive and tender). At the completion of the above work, the modification of the locomotive, construction of the compressed natural gas tender, and the fitting of the converted diesel engine will constitute a dual-fuel locomotive power-set suitable for demonstration. A comprehensive assessment of the limitations of the 251 engine in the dual-fuel mode was also carried out; the findings and recommendations form the basis of subsequent research and development. The application of the dual-fuel system controls to be investigated is expected to give the Bombardier locomotive equal power in the diesel and dual-fuel modes. In addition, the requirements and selection of the potential test and demonstration site were made along with expressions of interest from the participants of the program. 7 refs., 10 figs.

7869 **Locking apparatus for gate valves.** Fabyan, J.; Williams, C.W. To Dept. of Energy, Washington, DC. USA Patent 4,784,037. 15 Nov 1988. Filed date 28 Dec 1982. Int. Cl. F15B 15/26. vp Available from Patent and Trademark Office, Box 9, Washington, DC 20232.

This patent describes a locking apparatus for fluid operated valves having a piston connected to the valve actuator which moves in response to applied pressure within a cylinder housing having a cylinder head, a catch block is secured to the piston, and the cylinder head incorporates a catch pin. Pressure applied to the cylinder to open the valve moves the piston adjacent to the cylinder head where the catch pin automatically engages the catch block preventing further movement of the piston or premature closure of the valve. Application of pressure to the cylinder to close the valve, retracts the catch pin, allowing the valve to close. Included are one or more selector valves, for selecting pressure application to other apparatus depending on the gate valve position, open or closed, protecting such apparatus from damage due to premature closing caused by pressure loss or operational error.

3303 Electric-Powered Systems

Refer also to citation(s) 7188

7870 (AIL–TP8307E) **Aluminium-air (salt-water) battery for vehicles: Final report.** Strong, D.S. Alcan International Ltd., Montreal, PQ (Canada). Apr 1987. 150p. (MICROLOG–89-04033). Available from PC Transport Canada, Library and Information Centre, Place de Ville, Tower C, Ottawa, ON, CAN K1A 0N5; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

This report discusses the development of a 12-V, 250-W aluminium-air (salt water electrolyte) battery and its use to demonstrate the concept of range extension in electric vehicles using two types of batteries. Two 12-V 20-A multicell aluminum-air batteries were constructed and tested in a 24-V series configuration. They yielded 100 Wh/kg and 15 W/kg. The problems of heat removal, hydrogen dispersal and by-product management were resolved. The batteries were then placed in parallel-with lead-acid batteries in a 24-V gold cart. A microprocessor-based control device (appendix A) was developed for the aluminum-air battery to trickle-charge the lead-acid battery. The hybrid system more than doubled the range of the vehicle as compared to that obtained using lead-acid batteries only, for an equal mass and similar capacity rating. The cost of this new means of propulsion is briefly discussed in appendix B. 68 figs., 11 tabs.

7871 (DOE/NV/10366–10) **DSEP maintenance manual supplement for the NVH and TB-2 vehicles.** Canini, D.; DiBartolomeo, R.; North, A.; St. John, D. Eaton Corp., Detroit, MI (USA). Corporate Research and Development-Detroit Center. Sep 1989. 28p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC07-84NV10366. Order Number DE90003404. Available from NTIS, PC A03/MF A01 - OSTI.

This maintenance manual supplement covers maintenance and vehicle support information for the DSEP electric minivans additional to that contained in the Operations and Maintenance Manual of August 1989. This supplementary information is not required for day to day operation and maintenance but may be useful over the course of months and years to keep the DSEP vehicles operational. The supplement is intended to capture maintenance, repair and support procedures well understood at the time of completion and delivery by Eaton for possible future use by both EG&G Idaho and Eaton.

3307 Emission Control

7872 (ETDE-mf–0732398) **Specific problems of diesel exhaust sampling and measurement.** Winckler, J.; Lach, G. Volkswagenwerk A.G., Wolfsburg (Germany, F.R.). 1988. 27p. (In German). Order Number DE90732398. Available from NTIS (US Sales Only), PC A03/MF A01.

The results of exhaust gas and consumption tests of motor vehicles are still showing considerable faults. Unclear definitions and insufficiently specified testing methods and measuring instruments as well as insufficient possibilities of calibration are the reasons for this. Very large uncertainties frequently occur above all when determining the emission values of hydrocarbon and particles from diesel engined vehicles, in particular if the measurements are carried out by various testing institutes. In addition to this, systematic faults arise which are caused by various influences not yet definitely clarified. In the future it will primarily depend on chance if diesel engined vehicles pass the particle emission tests if the limiting values are reduced further or the Europe driving curve combined with the valid US testing method is applied. Improving the situation would only be possible by improving the testing methods. Basic suggestions are existing. But all relevant efforts are only useful if the authorities are willing to accept such improvements, to apply them themselves and to integrate them into the regulations. Further investigations are required to ensure that testing methods supply reliable results as well as that they can be applied in general and not only for certain concepts. (orig.).

7873 (NEI-DK–234) **NOx-emission from stationary natural gas-fired motors and turbines.** Energiministeriets Energiforskningsprogram. Miljoe og restprodukter. Noerregaard, A. DK-Teknik, Soeborg (Denmark). Sep 1989. 87p. (In Danish). Contract EM-1323/86-9. Order Number DE90728102. Available from NTIS (US Sales Only), PC A05/MF A01.

EFP-86.

It is shown that thermal oxidation of the air's nitrogen content is the most significant source of emission of nitrogen oxides from natural gas-fired turbines and engines. Maximum allowed content of nitrogen oxides in emission in relation to various countries are shown. A survey of possible methods of reduction of NOx emission is presented. Tabels are offered showing characterization of NOx emission from conventional and retrofitted turbines and motors. Currently in Denmark, it is expected that development will be towards the utilization of lean burning in natural gas-fired turbines and smaller engines, and also of 1-operation with three-way catalysators. In the case of larger engines the tendency is to recommend selective catalytic flue gas cleaning using ammonia. (AB) 48 refs.

7874 (SNV–3577) **Investigation of two diesel particle filters - one of wire-mesh type, the other of ceramic foam type.** Graegg, K.; Lundstroem, L.; Egebaeck, K.E. National Swedish Environmental Protection Board, Solna (Sweden). Feb 1989. 102p. (In Swedish). Order Number DE90728325. Available from NTIS (US Sales Only), PC A06/MF A01.

The effect of the filters on exhaust gas pollution was investigated. Both filter showed good filtration results. The PAH exhausts decreased in the particle phase and increases possibly in the gas phase. The mutagenesis test produced doubtful results. The amounts of unburnt fuel and unburnt oil in the particles decreased with both filters. The NO_2 share of NO_x increased with the wire-mesh filter because of the catalytic coating. A corresponding effect was not noted with the foam filter. With the wire-mesh filter installed in a city bus it was noted that this filter regenerated without special measures to prevent regeneration. Regeneration tests with the foam filter were not performed.

7875 (STU–85-3614) **Catalytic purification of car exhausts with a catalyst modified with regard to influence of methanol and its oxidation products.** Schoecen, N.H. (Chalmers Tekn. Hoegskola, Goeteborg (SE)). Swedish National Board for Technical Development, Stockholm (Sweden). 15 Apr 1989. 73p. (In Swedish). Order Number DE90728331. Available from NTIS (US Sales Only), PC A04/MF A01.

The aim of the project was to study which catalytic materials that could be employed in exhaust gas purification for vehicles operated on methanol containing fuels. Platinum is of course active but the oxidation of formaldehyde is strongly restrained by the presence of carbon monoxide. Several basic metal oxides show good catalytic activity and also tungsten carbide. In the case of the latter the activity is initially good but it decreases relatively quick. The nobel metal properties of tungsten carbide implies that this catalyst would possess better properties as a three-way catalyst. To obtain a realistic conception of a possible application in exhaust gas connection, all studies were done at the space velocity 35000/h, i.e. a contact time of c. 0.1 seconds. A literature survey is presented separately in appendix (74 refs.).

7876 (STU–87-3794) **Emissions from heavy vehicle engines: Development of particle traps for diesel exhaust gases.** Norstroem, Aa. (Tekniska Hoegskolan, Luleaa (SE)); Nordstroem, F.; Renberg, O. Swedish National Board for Technical Development, Stockholm (Sweden). 1989. 25p. (In Swedish). Project STU-742-87-3794. Order Number DE90728280. Available from NTIS (US Sales Only), PC A03/MF A01.

This literature study is based mainly on material from SAE conferences held in Detroit 1985-1988. Different filter systems for diesel exhaust gases are reviewed. It is concluded that most filters achieve an efficient separation of particulates, but that the regeneration of the filters is difficult. The reliability needed for continuous operation is not yet achieved.

7877 (VW-FMT–8902V/5) **Measurements of SO_2 and sulfate concentrations in car exhaust using ion chromatography.** Hartung, A.; Behte, A.; Postulka, A. Volkswagenwerk A.G., Wolfsburg (Germany, F.R.). Abt. Forschung und Entwicklung. 9 Jan 1989. 30p. (In German). Order Number DE90732334. Available from NTIS (US Sales Only), PC A03/MF A01.

In the framework of the analysis of non-limited exhaust gas components, an ion chromatography system is used for the detection of inorganic trace components. Processes for the detection of sulphur

dioxide and sulphate are developed, and the process coefficients are compared with those of the detection methods used so far (barium perchlorate titration for SO_2, barium chloranilate (BCA) method for sulphates). In the detection of SO_2, ion chromatography (IC) is comparable to titration with respect to expenditure and sensitivity. It offers, however, better possibilities for an automatization of the detection. In comparison with the BCA method, IC offers a better selectivity of the detection of sulphate since the BCA method is sensitive in transverse direction to the nitrate contained in the particle extracts and to organic components. The detection limit of the IC, however, is not sufficient for the direct detection of the sulphate in the particle extracts, which has to be compensated by a preconcentration of the samples in an additional step. (orig.).

3308 Alternative Fuels

7878 (ORNL/FTR–3490) **[Alcohol and blends as motor fuels]: Foreign trip report, November 11, 1989–November 18, 1989.** McGill, R.N. Oak Ridge National Lab., TN (USA). 4 Dec 1989. 15p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC05-84OR21400. Order Number DE90003517. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The traveler participated in the 11th meeting of the Executive Committee on Alcohols and Alcohol Blends as Motor Fuels (International Energy Agency). Participating countries in addition to the US are Canada, Italy, Finland, Japan, Sweden, New Zealand (absent). A representative of West Germany was in attendance as an observer and also to make a technical presentation. The status of three existing annexes was reviewed and two new annexes were approved in principle with details to be discussed in the next meeting. The traveler extended an invitation for the committee to hold its next meeting in June 1990 in Los Angeles, California. In other informal discussions during the travel period, the traveler learned that the organizing committee of the International Symposium on Alcohol Fuels wishes for the US to host the symposium in 1993 and is enlisting the aid of the traveler in seeking support in the US for this proposition.

7879 (ORNL/TM–11401) **Results from the third year of operation of the Federal Methanol Fleet at Lawrence Berkeley Laboratory.** McGill, R.N. (Oak Ridge National Lab., TN (USA)); West, B.H.; Hillis, S.L.; Hodgson, J.W. Oak Ridge National Lab., TN (USA). Dec 1989. 29p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC05-84OR21400. Order Number DE90003306. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Lawrence Berkeley Laboratory has completed three years of operation of ten vehicles for the Federal Methanol Fleet Project; five of the vehicles are fueled with methanol. Nearly 74,000 miles were accumulated on the ten vehicles during the third year, bringing the total for three years to over 280,000 miles. The five gasoline cars in the project at Berkeley have been retired from service by the General Services Administration, but the five methanol cars will continue to be monitored. Recent emissions tests of the methanol cars revealed higher emissions than when the cars were originally tested in 1985, and evidence suggests that there has been some deterioration of emissions control by the catalytic converters. Rates of accumulation of wear metals in the lubricating oil of the methanol engines improved during the third year; only iron remains appreciably elevated in the oil when compared to that of the gasoline engines. Drivers continued to express a high degree of satisfaction with the performance of the methanol cars as compared to that of the gasoline cars. 6 refs., 13 tabs.

7880 **Advanced technologies for reduced CO_2 emissions.** Steinberg, M. (Brookhaven National Lab., Upton, NY (US)). vp of The 8th Miami international conference on alternative energy sources. Volume 1-2 (Condensed Papers). Vezioglu, T.N. Clean Energy Research Inst. University of Miami, Coral Gables, FL (1988). (CONF-871204–: 8. Miami international conference on alternative energy sources, Miami Beach, FL (USA), 14-16 Dec 1987).

Studies made for the Carbon Dioxide Research Division of the U.S. Department of Energy on technologies that would reduce CO_2 emissions for the purpose of mitigating the global greenhouse effect are as follows: fossil fuel substitution, burning more natural gas instead of coal so as to emit half the CO_2 per unit energy compared to coal, nuclear and solar energy substitution which eliminates CO_2 emissions altogether, remove, recover, utilize, and dispose of CO_2 from power plants, improve fossil energy utilization and conversion efficiencies, and utilize fossil fuels without generating CO_2. Some conclusions are as follows: use of methane fuels is limited due to projected limited resource; nuclear fission is limited because of unsolved safety problems, and solar energy is limited by its low intensity, cost of removal, recovery, and disposal in the ocean of CO_2 from utility plants will double the cost of electrical energy and could reduce global emission only by 30%. Markets for utilization of CO_2 in products are too small to absorb the large quantities of CO_2 from the energy market. Recycling CO_2 requires using problematical nuclear or solar energy, application of improved energy conversion and utilization technologies could reduce emission by as much as 60% in the year 2050 and yield a return on investment of 10% due to fuel savings alone, and converting fossil fuels by advanced cracking process to carbon and hydrogen and utilizing only the hydrogen while storing the carbon for possible further use would eliminate CO_2 emissions.

35 ARMS CONTROL

3502 Proliferation

7881 (GAO/RCED–89-116) **Nuclear nonproliferation: Better controls needed over weapons-related information and technology.** General Accounting Office, Washington, DC (USA). Resources, Community and Economic Development Div. 1989. 39p. Available from US General Accounting Office, PO Box 6015, Gaithersburg, MD 20877.

The Department of Energy has taken some actions to implement a 1981 congressional mandate to limit the dissemination of unclassified information related to atomic defense activities. Nevertheless, sensitive countries–communist-controlled nations, countries suspected of developing nuclear weapons, or those viewed as a national security risk–have obtained information dealing with detonators, explosives, and firing sets that could assist or enhance nuclear weapons development. Foreign nationals obtain some information directly from DOE's weapons laboratories; DOE does not require the laboratories to track these requests. DOE recognizes that continuing to disseminate some unclassified information raises questions about its compliance with U.S. nonproliferation policy and in January 1989 issued internal guidance to identify data that should not be distributed to proliferation-risk countries.

3503 Verification

7882 (CONF-890554–3) **Arms control treaty verification: Neutron radiographic techniques.** DeVolpi, A. Argonne National Lab., IL (USA). [1989]. 5p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-31109-ENG-38. From 3. world conference on neutron radiography; Osaka (Japan); 14-18 May 1989. Order Number DE90003791. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Bilateral and multilateral arms control treaties are placing increasing demands on technical means for on-site verification. Radiation detection and imaging are important, especially when verification involves nuclear warheads. Neutron interrogation techniques are particularly useful in fissile material verification. The role of neutron radiographic imaging must be balanced between acquisition of sufficient information for effective verification and the avoidance of unneeded information that would be overly intrusive. 4 refs.

36 MATERIALS

Refer also to citation(s) 6673

7883 (INIS-SU–133/A) **Physics of radiation defects and radiation materials science. Scientific-technical collection.** Voprosy atomnoj nauki i tekhniki. v. 4(46). Gosudarstvennyj Komitet

po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. 74p. (In Russian). Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

Individual papers in this collection are separately indexed.

7884 (SERI/CP–211-3550, pp. 137-144) **Characterization of chalcopyrite materials for use in thin film heterojunction devices.** Albin, D.S.; Hallak, H.; Tuttle, J.R.; Noufi, R. Solar Energy Research Inst., Golden, CO (USA). [1989]. (CONF-890851–: Polycrystalline thin film program meeting, Lakewood, CO (USA), 16-18 Aug 1989). In *Proceedings of the polycrystalline thin film program meeting.* Order Number DE89009457. Available from NTIS, PC A10/MF A01.

The primary goal of this work was to quantify the effects of processing on the resulting microstructure and composition of multisource evaporated polycrystalline I-III-VI_2 chalcopyrite-based $CuGaSe_2$ and $CuInSe_2$ thin films. A subsequent goal was to determine the effects of this latter characterization on the optical/electrical behavior of the films. Secondary phase formation was identified in both $CuInSe_2$ and $CuGaSe_2$ by direct observation of extraneous XRD lines as well as optically in the form of sub-band absorption. The existence and nature of secondary phases has also been studied by treatments in sodium cyanide solutions.

3601 Metals and Alloys

Refer also to citation(s) 6521, 6548, 6625, 6684, 6955, 6973, 7048, 7049, 7482, 7512, 7525, 7547, 7551, 7554, 7562, 7622, 7996, 8000, 8106, 8199, 8350, 8802, 8940, 8941, 8942, 8943

7885 (BMU–1988-203) **Evaluation and analysis of data with a view to safety-relevant problems and to the consideration of these problems in the further development of the catalogue of nuclear technical codes. 1. technical report. Fundamentals for fatigue fracture analysis in the catalogue of nuclear technical standards.** Schriftenreihe Reaktorsicherheit und Strahlenschutz. Ergebnisberichte, Untersuchungen, Studien, Gutachten. Eisele, U.; Roos, E. Bundesministerium fuer Umwelt, Naturschutz und Reaktorsicherheit, Bonn (Germany, F.R.); Stuttgart Univ. (Germany, F.R.). Staatliche Materialpruefungsanstalt. Dec 1987. 110p. (In German). Contract BMU SR 357;MPA 837 300. Available from Available from GRM Werbeberatung - Werbemittlung - PR, Eggenstein-Leopoldshafen, (Germany, F.R.).

With the methods of elastic and plastic fracture mechanics, the behaviour of small and large samples can be precalculated precisely and safely within a wide range of material toughness. The recommendations for safety-relevant fracture-mechanical error analyses may be summed up as follows: The strength characteristic values on which the calculation is to be based must describe the case to be evaluated accurately (direction of stress, temperature). The fracture-mechanical values for crack initiation on which the calculation is to be based must be physical values, i.e. they must be transferable material parameters. The J_i value must be used for crack initiation. The calculation can only be done for initiation. At present, the calculation of stable crack growth before instability on the basis of crack resistance curves cannot be done with certainty. (orig./DG).

7886 (BMU–1988-204) **Evaluation and analysis of data with a view to safety-relevant problems and to the consideration of these problems in the further development of the catalogue of nuclear technical codes. 6. technical report. Status report on stress-induced cracking corrosion in pressure components made of ferritic materials (BWR reactors).** Schriftenreihe Reaktorsicherheit und Strahlenschutz. Ergebnisberichte, Untersuchungen, Studien, Gutachten. Deimel, P.; Iskluth, B.; Blind, D. Bundesministerium fuer Umwelt, Naturschutz und Reaktorsicherheit, Bonn (Germany, F.R.); Stuttgart Univ. (Germany, F.R.). Staatliche Materialpruefungsanstalt. Dec 1987. 101p. (In German). Contract BMU SR 357;MPA 837 500. Available from Available from GRM Werbeberatung - Werbemittlung - PR, Eggenstein-Leopoldshafen, (Germany, F.R.).

A whole lot of the operational cracks found are traced back, at least in part, to the interaction between transient operating stress and the corrosive influence of the medium, and attributed to the mechanism of expansion-induced crack corrosion. The investigations concentrate on the 'slip dissolution' model, hydrogen embrittlement, the model of 'environmentally-assisted cleavage', and on relevant influencing variables. Operational cracks are compared with simulation tests in autoclave, low-cycle and corrosion fatigue tests. (DG).

7887 (CEGB-RD-B–6085/R88) **Results of CEGB participation in the EGF round-robin on the measurement of crack growth fracture resistance.** Neale, B.K.; Abbott, K.R.; Havel, R.; Smith, R.F.; Akhurst, K.N.;. Central Electricity Generating Board, Berkeley (UK). Berkeley Nuclear Labs. Dec 1988. 43p. Order Number DE90611885. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

This report describes the results of CEGB participation in a round-robin to validate the European Group on Fracture (EGF) recommendations for determining the fracture resistance of ductile materials. Tests were performed on medium and high toughness materials and the results used to assess the performance of the EGF procedure. Several areas of concern were identified and where possible solutions are proposed. (author).

7888 (CEGB-RD-B–6092/R89) **An analysis of small clusters formed in thermally aged and irradiated FeCu and FeCuNi model alloys.** Buswell, J.T. (UKAEA Harwell Lab. (UK). Materials Development Div.); English, C.A.; Phythian, W.J.; Hetherington, M.G.; Smith, G.D.W.; Worrall, G.M.;. Central Electricity Generating Board, Berkeley (UK). Berkeley Nuclear Labs. Jan 1989. 35p. (PWR-RDMC-MWG-P–(88)199M). Order Number DE90611956. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

the pressure vessel of a pressurised water reactor, containing copper impurities, can be embrittled by the radiation-enhanced formation of copper-rich clusters during operation at 290^{0}C. Precipitation has been studied in FeCu and FeCuNi alloys thermally aged for up to 10h at 550^{0}C or irradiated to doses up to 6.95 x 10^{19}n.cm^{-2} (E > 1 MeV) at 290^{0}C. For the thermally aged alloys the most notable results include the clear observation of copper rich precipitates, evidence for the retention of a significant copper fraction in solid solution at the peak of hardening, evidence for a bimodal distribution of particle sizes in the overaged condition, which was enhanced by the presence of Ni, and evidence for a Ni "shell" around the precipitates in the ternary alloy. For the irradiated alloys the FeCu matrix was virtually depleted of copper at the lowest dose but copper was retained to the highest dose in FeCuNi. The amount of Ni associated with the irradiation produced precipitates was significantly higher than for those produced thermally, however it has not been established whether this was within the particles or in the form of a "shell". The results are discussed in the light of the observed changes in hardness properties. (author).

7889 (CEGB-RD-B–6107/R89) **Factors influencing the growth of cracks from defects in CDFR specification 316 stainless steel thermal shock specimens.** Cordwell, J.E.;. Central Electricity Generating Board, Berkeley (UK). Berkeley Nuclear Labs. Jan 1989. 56p. (SIWG-LASG-P–(89)382). Order Number DE90611886. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

The growth of cracks from spark machined slits and gouged grooves has been studied in a CDFR specification cast of 316 stainless steel under thermal shock conditions using sodium as the heat transfer medium. Comparative uniaxial creep fatigue tests have also been performed in servohydraulic machines under isothermal conditions. The cycles used for the thermal shock tests consisted of step increases in temperatures of between 75 and 300 C followed by tensile holds at 600 C of duration 0.05 to 24 hours, and finally slow cooling to the initial temperature ready for the next cycle. The results are presented showing the influence on crack growth of strain range, hold time, number of cycles, types of defect and ferrite stringer direction. (author).

7890 (CEGB-RD-B–6108/R89) **The effect of ageing on crack growth in thermal shock of 316 stainless steel specimens: interim report.** Cordwell, J.E.;. Central Electricity Generating Board, Berkeley (UK). Berkeley Nuclear Labs. Jan 1989. 18p. (SIWG-LASG-P–(89)383). Order Number DE90611887. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

Initial results of the effect of ageing on crack propagation in creep fatigue for two casts of 316 stainless steel are reported and compared with previous observations in the literature. Specimens from one cast were available in the solution treated condition and after ageing in the laboratory for 26000 hours at 550C. The other cast had been aged in service at 595C for a similar period of time. Some of these specimens were re-solution treated prior to testing. All the specimens contained spark machined slits and were tested either in thermal shock, using a step increase in temperature of 150C, or in uniaxial creep fatigue. The tests consisted of 500 cycles with a tensile hold at 600C of 2 hours (thermal shock) or 1 hour (uniaxial). The solution treated cast and the re-solution treated service aged cast produced similar crack growth rates for similar stress intensity factor ranges. For similar stress intensity factor ranges crack growth rates in the aged condition were lower than those in solution treated material, as found in other studied. (author).

7891 (CEGB-RD-M-1773/RR88) **Relationship between arc voltage current and arc length in TIG welding.** Drew, P.N.; Deam, R.T.;. Central Electricity Generating Board, Southampton (UK). Marchwood Engineering Labs. Jan 1989. 22p. Order Number DE90611823. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The relationship between arc voltage, arc length and current in Tungsten Inert Gas welding has been investigated. It was not possible to determine a correlation between arc voltage, current and arc length because of the inherent variability in the experimental results. A typical value for the error in controlling the arc length using arc voltage was calculated and found to be $\pm$ 0.5mm. The variation in arc voltage at constant conditions has two components, long term and short term. Long term is the variation in voltage between welds, short term is voltage variation within a few seconds. Both are about 5% of the total arc voltage. Since only a fraction of the arc voltage depends on arc length, this leads to a much larger variation in arc length if Arc Voltage Control (AVC) is used to control arc length (about 15% in each case at 3mm arc length). A weld procedure based on AVC is likely to yield a different variability in weld bead geometry from one based on constant arc length. (author).

7892 (CEGB-RD-M-1783/RR89) **The effect of cast-to-cast variations on the quality of thin section nickel alloy welded joints.** Lambert, J.A.;. Central Electricity Generating Board, Southampton (UK). Marchwood Engineering Labs. Feb 1989. 36p. Order Number DE90611824. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The welding behaviour of 26 commercial casts of Alloy 800 has been quantified for mechanised, autogenous, full penetration, bead-on-strip tungsten inert gas welding tests. Weld front and back widths have been measured and correlated with minor element variations. Casts with similar welding responses have been sorted into groups. The behaviour of the weld pool, surface slags and arc have been compared and a convection controlled model has been used to account for differences between the groups of casts. The main factors governing laboratory process control variability have been identified and a statistical method has been used to identify all the components of weld variance. An optimum size of welding test matrix has been proposed to determine typical cast-to-cast variations at high significance levels. (author).

7893 (CONF-891119-18) **Effects of ion dose on the morphology and crystallization of amorphous germanium.** Wang, L.M.; Birtcher, R.C.; Rehn, L.E. Argonne National Lab., IL (USA). Nov 1989. 7p. Sponsored by U.S. DOE Energy Research. DOE Contract W-31109-ENG-38. From Materials Research Society fall meeting; Boston, MA (USA); 27 Nov - 2 dec 1989. Order Number DE90003564. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

1.5 MeV Kr^+ irradiation of polycrystalline Ge at room temperature, and subsequent annealing were carried out with in situ TEM observations. After a Kr^+ dose of 1.2×10^{14} ions/cm^2, Ge in the electron transparent region was completely amorphized. Continuous irradiation of the amorphized Ge resulted in a high density of small cavities. These cavities, first observed after 7×10^{14} ions/cm^2 with an average diameter of ~3 nm, grew into large (~50 nm) irregular-shaped holes, transforming the irradiated Ge into a sponge-like material after 8.5×10^{15} ions/cm^2. The crystallization temperature and the morphology of the crystallized Ge after annealing were found to be dependent on the Kr^+ dose. The sponge-like structure was retained after crystallization at ~600°C. 18 refs., 6 figs.

7894 (CONF-8910222-9) **Cast stainless steel aging: Mechanisms and predictions.** Chopra, O.K.; Chung, H.M. Argonne National Lab., IL (USA). Oct 1989. 30p. Sponsored by Nuclear Regulatory Commission. DOE Contract W-31109-ENG-38. From 17. water reactor safety information meeting; Rockville, MD (USA); 23-25 Oct 1989. Order Number DE90003772. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Charpy-impact and J-R curve data are presented for several experimental and commercial heats, as well as for reactor-aged material of CF-3, CF-8, and CF-8M grades of cast stainless steel. The effects of material variables on the embrittlement of cast stainless steels are evaluated. In general, the low carbon CF-3 grades of cast stainless steels are the most resistance and molybdenum-containing high-carbon CF-8M grades are the most susceptible to low-temperature embrittlement. The ferrite morphology has a strong effect on the extent or degree of embrittlement, while material composition influences the kinetics of embrittlement. The kinetics of embrittlement can vary significantly with small changes in the constituent elements of the cast material. The mechanisms of embrittlement have also been established. Mechanical property data have been analyzed to develop the procedure and correlations for predicting the kinetics and extent of embrittlement of reactor components from known material parameters. The method and examples of estimating the impact strength and fracture toughness of cast components during reactor service are described. The lower-bound values of impact strength and fracture toughness for cast stainless steels at LWR operating temperatures are defined. 30 refs., 17 figs., 3 tabs.

7895 (DPST-60-319) **Physical annd mechanical properties of Al-Li.** Savannah River Lab., Aiken, SC (USA). 31 May 1960. 13p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. Order Number DE90003906. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The tensile strength, yield strength, and hardness of as-extruded aluminum-lithium alloys containing up to 7.4 w/o lithium decrease as the temperature of testing increases. These properties, in general, increase as the lithium content increases. The hot hardness can be used to predict the yield strength and ultimate strength within the temperature range of room temperature to 200°C to an accuracy of $\pm$10%. Mechanical properties of aluminum-lithium alloys containing up to 2 w/o lithium are not affected appreciably by heat treatment. With alloys containing 3 w/o lithium or more, as-extruded and aged alloys showed higher strength than either solution-quenched or dead-annealed alloys of similar composition. 8 figs., 1 tab.

7896 (DPST-61-209) **Strain-induced diffusion and precipitation in aluminum-lithium alloys during creep.** Marshall, R.P. Savannah River Lab., Aiken, SC (USA). 28 Feb 1961. 9p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. Order Number DE90003913. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

This paper describes the observation of lithium diffusion to preferred grain boundaries within the metal specimen; the paper was revised at the suggestion of the reviewer, to show clearly that the grain boundary effect was a second phase and not intergranular fracture. Strain-induced diffusion may be the explanation for the grain boundary layers of LiAl compound observed in Mark VI slugs after postirradiation annealing, and the similar layers that formed in control rods during irradiation. 1 ref., 4 figs.

7897 (EMR/CANMET-PMRL85-71(TR)) **An evaluation of weld metal toughness for low temperature offshore structure applications.** Gianetto, J.A.; Braid, J.E.M. Canada Centre for Mineral and Energy Technology, Ottawa, ON (Canada). Dec 1985. 27p. (MICROLOG-89-04608). Available from PC Canada Dept. of Regional Industrial Expansion, Library (CEIB), 235 Queen St., Ottawa, ON, CAN K1A 0H5; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

Two welds were prepared in 25 mm thick C-Mn microalloyed steel plate using the shielded-metal-arc (SMA) and submerged-arc

(SA) welding processes. The toughness properties of the two welds were evaluated using the Charpy and crack tip opening displacement (CTOD) tests. The Charpy notch toughness of the SMA weld was slightly higher than the SA weld. The CTOD properties of the SA weld were superior to those of the SMA weld in tests conducted at 10^0 and -30^0C. The fractures in both welds were found to initiate from large (>1 μm) non-metallic inclusions and the differences have been explained using a model which considers notch tip acuity and the size distribution of inclusions. It is recommended that both a blunt notch-impact test (Charpy) and a sharp crack test (CTOD) be used to properly evaluate the toughness properties of welded joints. 19 refs., 10 figs., 9 tabs.

7898 (ETDE-mf–0732326) **Testing and further development of a measuring instrument for nondestructive corrosion testing of steel hoisting cables for underground applications. Final report.** Langebrake, F.; Naehring, G. Versuchsgrubengesellschaft m.b.H., Dortmund (Germany, F.R.). Sep 1988. 75p. (In German). Order Number DE90732326. Available from NTIS (US Sales Only), PC A04/MF A01.

The transceiver belt testing system was fully developed for the assessment of corrosion and cable-fracture damages resulted in conveyer belts. This has now made available a meassuring device in which the whole field of electronics is integrated in a transmitter and/or receiver bar. The device is intrinsically safe in its build-up; it is expected to be approved in 1988. Underground test measurements with the sample belt and with conveyer belts have revealed sufficient linear dependence on the mass of steel in the cables. A further number of studies dealt with the precise localization of the damage in the conveyer belt and with damage documentation with the help of a transportable X-ray apparatus. Other techniques described are the magneto-inductive technique of the Australian firm CBM, the X-ray transmission technique of RWTUeV (the Rheno-Westphalian Technical Control Association) and the radiometric technique of the Seifert company. (orig.).

7899 (ETDE-mf–0732335) **Influence of the parameters load sequence, sequence classification, sub-sequences and process irregularity of a Gaussian process on the life of a structural component of 3.1354 T3 and 3.4377 T761.** Ertelt, H.J. Stuttgart Univ. (Germany, F.R.). Fakultaet 9 - Luft- und Raumfahrttechnik; Stuttgart Univ. (Germany, F.R.). Inst. fuer Computeranwendungen. 23 Feb 1988. 289p. (In German). Order Number DE90732335. Available from NTIS (US Sales Only), PC A13/MF A01.

Since the physico-chemical mechanisms the interactions of which, in the end, cause the deterioration of structural components subjected to vibratory stress, are still unknown in many aspects, it is not yet possible to describe the life of a structural component in a general physico-mathematical model. Therefore, a realistic life estimate of a structural component is only possible in connection with experiments, which usually involves a high cost and time factor. For this reason an effort is made to limit experimental research to a necessary minimum by using semi-empirically deduced failure models. This, however, presupposes that the influence of the individual parameters of an operating stress on the deterioration of the structural component is known as accurately as possible. In this study, the influence of the different parameters of an operating load such as load sequence (load interaction effects), sequence classification, subsequence extent (peak factor) and process irregularity, was deduced from experiments and presented by means of a systematic alteration of the test sequence (stationary Gaussian process). By this, methods for the estimation of the life of structural components were obtained. From the tests on the influence of the subsequence extent (peak factor) of a sequence on the life of a structural component, possibilities were obtained for the life estimate (large subsequence extent) of a structural component from test data with a representative random sample (small subsequence extent). (orig./MM).

7900 (GKSS–88/E/71) **Determination of da/dN DeltaK (or DeltaK$_{eff}$) curves in the threshold range for steels of different strength in air and synthetic sea water.** Wellenkoetter, B.; Horstmann, M.; Schwalbe, K.H. GKSS-Forschungszentrum Geesthacht G.m.b.H., Geesthacht-Tesperhude (Germany, F.R.). 1988. 13p. (In German). (CONF-8812121–: 1988 materials testing conference, Bad Nauheim (Germany, F.R.), 1-2 Dec 1988). Available from Available from GKSS-Forschungszentrum Geesthacht GmbH, Geesthacht-Tesperhude (Germany, F.R.).

Reprint from Deutscher Verband fuer Materialpruefung e.V., Berlin (Germany, F.R.) (ed.): Proceedings of the materials testing conference 1988, p. 261-270.

The usual procedure in tests on crack extension in the threshold area is to decrease the force amplitude stepwise up to crack arrest while maintaining a constant R value (stress ratio) and to optically read the crack length. The result of this procedure is that in the crack length interval where a constant force amplitude is maintained the DeltaK increases according to the increase in crack length. This involves the fact that in principle an incorrect da/dN is assigned to a DeltaK value. Another method, which does not have the disadvantage of the force-controlled test procedure, is to control the tests by a constant DeltaK, i.e. to provide constant stress conditions at the crack tip. However, this requires the use of indirect measuring methods for the determination of the crack length and a computer-controlled test procedure. Both the alternating current method and the compliance method have proved successful as indirect methods for crack length measurement in air. (orig./MM).

7901 (GKSS–88/E/72) **Indirect methods of measurement in case of stress corrosion cracking of steel.** Wellenkoetter, B.; Horstmann, M.; Schwalbe, K.H. GKSS-Forschungszentrum Geesthacht G.m.b.H., Geesthacht-Tesperhude (Germany, F.R.). 1988. 13p. (In German). (CONF-8803249–: 20. session of the DVM working group on fracture mechanisms: corrosion and fracture, Frankfurt am Main (Germany, F.R.), 17-18 Mar 1988). Available from Available from GKSS-Forschungszentrum Geesthacht GmbH, Geesthacht-Tesperhude (Germany, F.R.).

Reprint from Deutscher Verband fuer Materialpruefung e.V., Berlin (Germany, F.R.) (ed.): Proceedings of the 20th meeting of the working group on fracture processes, topical subject: Corrosion and fracture, 1988, p. 383-392.

The alternating current process has proved to be a suitable method for crack length measurement in a corrosive environment. This process permits computer-controlled tests with DeltaK = constant for the analysis of the interaction between crack propagation and corrosion. When simultaneously used, the compliance method is suited to record the crack closing behaviour by means of measuring techniques. Crack closing due to plastic crack closing, caused by cover layers, can be observed and information about the time-dependent structural variation of the cover layer is obtained. Furthermore, it is shown by means of the compliance method that the rigidity of the sample changes due to the absorption of hydrogen. (orig.).

7902 (INIS-mf–11521) **Electronic structure of deep impurity centers in silicon.** van Oosten, A.B. Amsterdam Univ. (Netherlands). 20 Jun 1989. 150p. Order Number DE90705957. Available from NTIS (US Sales Only), PC A07/MF A01 - OSTI.

This thesis reports an experimental study of deep level impurity centers in silicon, with much attention for theoretical interpretation of the data. A detailed picture of the electronic structure of several centers was obtained by magnetic resonance techniques, such as electron paramagnetic resonance (EPR), electron-nuclear double resonance (ENDOR) and field scanned ENDOR (FSE). The thesis consists of two parts. The first part deals with chalcogen (sulfur, selenium and tellurium) related impurities, which are mostly double donors. The second part is about late transition metal (nickel, palladium and platinum) impurities, which are single (Pd,Pt) or double (Ni) acceptor centers. 155 refs., 51 figs., 23 tabs.

7903 (INIS-SU–133/A, pp. 3-6) **Accumulation of radiation defects in aluminium-tin alloy under low-temperature electron irradiation.** Arbuzov, V.L. (AN SSSR, Sverdlovsk (USSR). Inst. Fiziki Metallov); Davletshin, A.Eh.; Klotsman, S.M. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

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Interaction of interstitial atoms (ISA) and impurity tin atoms in aluminium was studied by measuring residual electric resistivity by the

method of inverse accumulation rate of radiation defects at irradiation temperatures from 54 K to 158 K. The aluminium-21 at. ppmSn alloy was irradiated in the linear electron accelerator at 5.5 MeV energy. It is shown that tin atoms are effective ISA traps. The relative capture radius for ISA by tin atoms is 0.6+-0.1 at 54 K. In the spectrum 2 of the annealing stage there is one peak at 150 K caused by dissociation of ISA-Sn atom complexes. The binding energy of such complexes is about 0.34 eV. At irradiation temperatures higher than 85 K, when dissociation of these complexes has begeen, a sharp decrease of the capture parameters is observed. 9 refs.; 2 figs.

7904 (INIS-SU–133/A, pp. 7-9) **Kinetics of radiation defects accumulation under impulse electron irradiation.** Arbuzov, V.L. (AN SSSR, Sverdlovsk (USSR). Inst. Fiziki Metallov); Davletshin, A.Eh.; Klotsman, S.M.; Podchinenov, I.E. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.
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The process of radiation defects accumulation under continuous and pulsed (10^{-8} pulse time, 10^{4} and 10^{6}) electron irradiation at 54 K temperature is studied on a computer. The defect generation rate is $10^{-8}...10^{-7}$ displ./(atxs). It is shown that the calculated results for continuous and pulsed irradiation are practically the same. So, processing of the measurement results by the urdely used method of inverse accumulation rate (IAR) for determining the capture radii of interstitial atoms by impurities can be carried out in the assumption of radiation continuity. Besides, although the IAR curve must have an S-like form, at low irradiation doses in some impurity concentration range the experimental results can be processed according to the linear law. 4 refs.; 4 figs.

7905 (INIS-SU–133/A, pp. 10-17) **Point defect-intestitial impurity complexes and their effect on radiation swelling of fcc-metals.** Ogorodnikov, V.V. (AN Ukrainskoj SSR, Kiev (Ukrainian SSR). Inst. Problem Materialovedeniya); Pokropivnyj, V.V.; Rakitskij, A.N. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.
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A mixed interatomic Cr-Fe and Cr-Nb potential is developed. Using the molecular dynamics method the energy and structural characteristics substitutinal impurities, impurity-vacancy and impurity-interstitial complexes in chromium and niobium, as well as the spontaneous recombination zone of the Frenkel pair in the presence substitutional impurities are calculated. The effect of the dimensional and energy discrepancy factor on these characteristics is analyzed. The enlargement (reduction) of the spontaneous recombination zone is observed, when an interstitial atom is captured by rather great (small) substitutional impurity, which has permitted to refine the mechanism of radiation swelling suppression by impurity complexes. 20 refs.; 10 figs.; 3 tabs.

7906 (INIS-SU–133/A, pp. 18-25) **Swelling of ferritic-martensitic steels containing helium under electron irradiation.** Ageev, V.S. (Vsesoyuznyj Nauchno-Issledovatel'skij Inst. Neorganicheskikh Materialov, Moscow (USSR)); Snajkers, M.; Turchin, S.I.; Alejnov, I.D. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.
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The effect of preliminarily injected helium on swelling of 15Kh12VM1BFR ferritic-martensitic steel was studied. Helium saturation up to 10 and $20x10^{-4}$ at. % was conducted on a cyclotron. Irradiation up to 30 dpa in the 370-470 deg C temperature range was carried out using a high-voltage electron microscope at 1 MeV electron energy. The irradiation area simultaneously covered ferrite and martensite grains. Ferrite swelling was higher than that of martensite, but it did not exceed 2 % in both phases. Helium saturation resulted in the temperature swelling peak shift towards higher temperatures. The comparison of the theoretical calculations with the experiment has shown that existing notions of origination of voids with a gas permit to describe the observed helium effect satisfactorily. 25 refs.; 7 figs.; 2 tabs.

7907 (INIS-SU–133/A, pp. 29-38) **Hydrogen induced changes in irradiated and nonirradiated stainless austenitic 0Kh16N15MZB type steel.** Platonov, P.A. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). Inst. Atomnoj Ehnergii); Tursunov, I.E.; Alekseev, S.I.; Levit, V.I.; Elesin, L.A.; Dorovskij, V.M. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.
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The hydrogen behaviour in irradiated and nonirradiated stainless steel 0Kh16N15MZB is experimentally studied. X-ray investigations were mainly carried out and, besides, mechanical tests and electron-microscopic analysis were conducted. It is shown that stainless steel hydridation results in formation of a strengthened near-surface layer containing two types of H_γ (fcc) and H_ϵ (hcp) hydride phases, which play the determinig role on steel cracking and resistance to hydrogen. The differences in the hydrogen behaviour in irradiated and nonirradiated steel are noted, and a simplified model of its cracking during hydridation is considered. The results on variation of properties of irradiated and nonirradiated steel caused by hydrogen are considered from the viewpoint of hydrogen capture. 20 refs.; 9 figs.; 3 tabs.

7908 (INIS-SU–133/A, pp. 39-43) **Study of material radiation porosity depending on technique and intensity of gas implantation.** Kekchidis, S.N. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.
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The gas effect on porosity development of an irradiated material depending on conditions of gas implantation is studied on the basis of the theory of binary clusters origination and gaseous porosity development in irradiated crystals taking into account gas mobility and finite solubility in the crystal, availability of heterogeneous sources of voids. It is established that the observed ambiguity of porosity parameters at equal gas concentrations and different character of its implantation can be explained by the difference in the conditions of void origination and growth governed by the technique of gas implantation. It is shown that the radiation induced porosity level at the given amount of implanted gas mostly depends on the way it has been implanted: before irradiation, in cold state and at the irradiation temperature; or along with irradiation, with different implantation intensities. In the case of preliminary implantation the void density will be less than in the case of coimplantation. In the second case the void density and swelling are highly sensitive to the implantation intensity, and depending on microstructural state of the material and irradiation conditions the intensity increase of gas implantation can result in the porosity level growth or its decrease. 13 refs.; 3 figs.

7909 (INIS-SU–133/A, pp. 44-52) **Effect of hydrostatic compression on helium voids in aluminium.** Sokurskij, Yu.N. (Vsesoyuznyj Nauchno-Issledovatel'skij Inst. Neorganicheskikh Materialov, Moscow (USSR)); Tebus, V.N.; Zudilin, V.A.; Tumanova, G.M. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.
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The results of electron microscopic study and measurements by the hydrostatic weighing method of the effect of uniform compression on helium porosity development in irradiated aluminium alloy, containing 0.5 to 1.16 at. % helium, are presented. It is shown that hydrostatic uniform compression of irradiated material at about $0.6T_{melt.}$ temperature leads to decreasing the size of voids at the same their concentration, i.e. decreasing helium swelling. Theoretical analysis of the phenomenon kinetics has shown that it is mainly self diffusion and slightly depends on the helium thermodynamic

and kinetic parameters in solution. The process considerably depends on helium thermodynamics in voids. It is shown that application of the ideal gas or Van-der-Waals equation leads to serious mistakes. Taking into account the equation of state of real gas a design model for describing the effect of uniform compression and development of helium voids is developed. The ordered arrangement of helium voids in the 111 planes at helium concentrations ≤ 2 at. % is observed. The crystallographic bond between the void lattice and matrix crystal lattice is investigated. 11 refs.; 10 figs.

7910 (INIS-SU–133/A, pp. 53-56) **Kinetic and diffusion stages of helium penetration in metals from low temperature gas-discharge He-H plasma.** Gurevich, M.E. (AN Ukrainskoj SSR, Kiev (Ukrainian SSR). Inst. Metallofiziki); Zhuravlev, A.F.; Larikov, L.N.; Ryasnyj, A.V. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

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The specific way of helium penetration (and other inert gases) under their irradiation by low-energy ions in glowing discharge plasma is discussed. The analysis of the experimental profile of helium distribution in irradiated aluminium has shown a deep helium penetration due to radiation induced diffusion. That is why while considering the deep penetration phenomenon the two basic stages are taken into account. The first stage is a kinetic one, when implantation of He^+ ions into the near-surface metal layers occurs. Then during ion retardation their radiation induced diffusion begins, i.e. the second stage. The expressions satisfactorily describing the experimental results and evolution of helium distribution at both stages are proposed. A possible mechanism of radiation induced diffusion is discussed. 24 refs.; 1 fig.

7911 (INIS-SU–133/A, pp. 57-61) **Temperature dependence of molybdenum sputtering under bombardment of nitrogen, oxygen and fluorine ions.** Afanas'ev, G.V. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Sukhumi (USSR). Fiziko-Tekhnicheskij Inst.); Diasamidze, Eh.M.; Kalinin, A.N. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

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The coefficients of molybdenum sputtering under irradiation by nitrogen, oxygen and fluorine ions at 100 keV energy and $1...5 \times 10^{18}$ cm^{-2} doses are determined. A great discrepancy is observed as compared with the values calculated according to the linear cascade model. The temperature dependences of sputtering coefficient are studied and activation energies of processes responsible for the sputtering coefficient variation are calculated. The analysis of the sputtering coefficient increment due to the sample temperature has shown that in the course of irradiation a dynamically equilibrium film of impurity atoms with bonds like those of a molecular crystal is formed in the near-surface layer. At temperature elevation it decomposes and the sputtering coefficient by nitrogen and oxygen is defined by double system sputtering. In the case of fluorine at 400 deg C the sputtering coefficient is close to that of pure molybdenum. 7 refs.; 3 figs.; 3 tabs.

7912 (INIS-SU–133/A, pp. 62-65) **Peculiarities of sputtering of multicomponent materials under irradiation with hydrogen plasma ions.** Gribanov, Yu.A. (AN Ukrainskoj SSR, Kharkov (Ukrainian SSR). Fiziko-Tekhnicheskij Inst.); Dikij, N.P.; Zhmurin, P.N.; Letuchij, A.N.; Matyash, P.P.; Opalev, O.A.; Ternopol', A.M.; Fedorenko, A.I. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

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The TiC and NbC graphite-based coatings perspective for power intensity units of the thermonuclear reactor first wall were irradiated by hydrogen plasma ions from an open steady-state discharge up to 5×10^{19} ions/cm^{-2} dose. Using the nuclear reaction method it was established that the near-surface layer was enriched with a heavy component: in the case of TiC-the initial To concentration is 70 %, after irradiation-85 %; in the case of NbC the initial Nb concentration is 52 %, after irradiation-80 %. The obtained results are discussed using the mechanism of prevailing sputtering of the heavy component during irradiation of multicomponent materials by light ions. 7 refs.; 3 figs.

7913 (INIS-SU–133/A, pp. 72-73) **Peculiarities of radiation-induced ν-phase precipitation structure in austenitic stainless steels.** Bryk, V.V. (AN Ukrainskoj SSR, Kharkov (Ukrainian SSR). Fiziko-Tekhnicheskij Inst.); Kiryukhin, N.M.; Neklyudov, I.M. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

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Short note. 5 refs.; 1 fig. CHROMIUM-NICKEL STEELS/physical radiation effects; CHROMIUM IONS; HIGH TEMPERATURE; ION BEAMS; LATTICE PARAMETERS; MICROSTRUCTURE; PHASE STUDIES; TITANIUM ADDITIONS

7914 (Juel–2274) **Texture analysis at metals and minerals and the determination of meteorite microstructures by neutron diffraction.** Hoefler, S. Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Inst. fuer Festkoerperforschung; Bonn Univ. (Germany, F.R.). Apr 1989. 112p. (In German). Order Number DE90732691. Available from NTIS (US Sales Only), PC A06/MF A01.

The four-circle diffractometer of Bonn University in the FRJ-2 reactor in Juelich is used for pole figure measurements for the texture and microstructure analysis. The high penetration depth allows measurements of big sample volumes. Computer programmes for the evaluation of the pole figures are developed. Investigations of geological and metallic samples are presented. (BHO).

7915 (KFK–4288) **Microstructural and fractographic investigations of a Nb-bearing martensitic 12% chromium-steel (DIN 1.4914) with a lowered nitrogen-content.** Materna-Morris, E. Kernforschungszentrum Karlsruhe G.m.b.H. (Germany, F.R.). Inst. fuer Material- und Festkoerperforschung; Kernforschungszentrum Karlsruhe G.m.b.H. (Germany, F.R.). Projekt Schneller Brueter. Jul 1989. 65p. (In German). Order Number DE90728838. Available from NTIS (US Sales Only), PC A04/MF A01.

The martensitic steel DIN 1.4914 is favored as structural material for Fast Breeder Reactors. For the use as wrapper tube a new delta-ferrite free melt was developed with a strongly reduced nitrogen - and a low carbon content for achieving a low ductile-to-brittle transition temperature (DBTT). The material was investigated systematically in its microstructure depending on the austenitization and the tempering. The microstructure influences the fracture behaviour of the steel. As a main result the fractures of tensile and impact tested samples are predominatly formed by the inclusions and the secondary precipitates. (orig.).

7916 (KFK–4297) **XPS and AES investigations of the adhesive bonding properties of thin titanium coatings.** Moers, H.; Mohr, J.; Klewe-Nebenius, H.; Pfennig, G. Kernforschungszentrum Karlsruhe G.m.b.H. (Germany, F.R.). Inst. fuer Radiochemie; Kernforschungszentrum Karlsruhe G.m.b.H. (Germany, F.R.). Inst. fuer Kernverfahrenstechnik. Jul 1988. 47p. Order Number DE90732693. Available from NTIS (US Sales Only), PC A03/MF A01.

The bonding properties of PMMA-microstructures on Ti-coated Cu-substrates after an oxidative treatment in alkaline hydrogenperoxide solution were investigated. In order to clarify the basic mechanism, surface analytical investigations by XPS-, AES-, and depth profile measurements have been performed. It was demonstrated that for optimum bonding a TiO_2 surface layer of ca. 30 nm thickness is necessary. Chemical effects as well as a mechanical bonding with open grain boundary structures (dimensions in the mum-range) could be ruled out as bonding mechanisms. A mechanical interlocking of the polymer with micropores (dimensions in the nm-range) of the oxidic overlayer is adopted as the most probable bonding mechanism. (orig.).

7917 (LA–11522-MS) **Elastic moduli of copper: Electronic structure contributions from pseudopotentials and full-potential linear muffin-tin orbital band structure calculations.** Straub, G.K.; Wills, J.M. Los Alamos National Lab., NM (USA). Nov 1989. 46p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-36. Order Number DE90004423. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The elastic moduli of copper have been determined from the electronic structure by using an empty core pseudopotential model and first-principles full-potential linear muffin-tin orbital (FPLMTO) band calculations. General second order stress-strain coefficients are determined from strain derivatives of the total energy. The pseudo-potential model includes d-state interactions and results in an effective pair-wise interaction between ions. In terms of the pair-wise interaction and its derivatives, formulas for the second order elastic constants are given. FPLMTO calculations are presented for the total energy and its derivatives of Cu based on a self consistent local density functional Hamiltonian with no shape approximation to the potential. Pseudopotential and FPLMTO results for the elastic moduli and their pressure derivatives are compared at pressures of zero and one Mbar. 13 refs., 9 figs., 6 tabs.

7918 (NUREG/CR–5408) **SEN wide-plate crack-arrest tests using A 533 grade B class 1 material: WP-CE test series.** Naus, D.J. (Oak Ridge National Lab., TN (USA)); Keeney-Walker, J.; Bass, B.R.; Iskander, S.K.; Fields, R.J.; deWit, R.; Low, S.R. III. Nuclear Regulatory Commission, Washington, DC (USA). Div. of Engineering; Oak Ridge National Lab., TN (USA); National Inst. of Standards and Technology, Gaithersburg, MD (USA). Nov 1989. 119p. Sponsored by Nuclear Regulatory Commission. DOE Contract AC05-84OR21400. (ORNL/TM–11269). Available from NTIS, PC A07/MF A01 - GPO; OSTI; INIS.

Two 102-mm-thick wide-plate crack-arrest tests (WP-CE series) are discussed in this report. Each test used a 1 x 1 x 0.1 m thick single-edge notched specimen (a/w = 0.2) fabricated from A 533 grade B class 1 steel that was subjected to a linear thermal gradient along the plane of crack propagation. The tests were conducted at the National Institute of Standards and Technology and were designed to provide fracture-toughness measurements at temperatures approaching or above the onset of the Charpy upper-shelf regime in a rising toughness region and with an increasing driving force. Results obtained from these tests have produced crack-arrest toughness values well above the limit recognized by the current ASME guidelines (220 MPa·$\sqrt{m}$) with arrests occurring at 58 to 95°C above the material RT_{NDT} (–35°C). The fracture data support (1) the use of fracture mechanics concepts to analyze cleavage run-arrest events, (2) the treatment of cleavage run-arrest and ductile fracture modes as separate events, and (3) the fact that cleavage arrest occurs above the ASME limit. 47 refs., 87 figs., 13 tabs.

7919 (ORNL/TM–11281) **Metals and Ceramics Division Materials Sciences Program annual progress report for period ending April 30, 1989.** Stiegler, J.O. (comp.). Oak Ridge National Lab., TN (USA). Sep 1989. 298p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004371. Available from NTIS, PC A13/MF A01 - OSTI; GPO Dep.

This report summarizes the activities of the Materials Sciences Program in the Oak Ridge National Laboratory (ORNL) Metals and Ceramics Division for the period July 1, 1987 to April 30, 1989. The program is directed at uncovering principles for the scientific design of materials. The efforts emphasize three classes of materials: high-temperature metallic alloys based on intermetallic compounds, structural ceramics, and radiation-resistant alloys. The principal elements of Materials Science and Engineering — synthesis/processing, characterization, properties, and performance — are incorporated in all of these programs to achieve a full understanding of the relationships among the elements. A first-principles theory provides understanding of the structure of alloy systems. Surfaces and interfaces of ceramic systems are investigated through ion beam and molecular beam epitaxy activities. Major emphasis is placed on structural characterization capabilities to furnish the link between processing and performance.

7920 (SAND–89-2703C) **Shock-induced reaction synthesis of aluminides and silicides.** Thadhani, N.N. (New Mexico Inst. of Mining and Technology, Socorro, NM (USA). Center for Explosives Technology Research); Costello, M.J.; Song, I.; Work, S.; Graham, R.A. Sandia National Labs., Albuquerque, NM (USA). [1989]. 13p. Sponsored by U.S. DOE Defense Programs; National Science Foundation. DOE Contract AC04-76DP00789. DMR-8713258. (CONF-891024–7: The Metallurgical Society fall meeting: materials week, Indianapolis, IN (USA), 1-5 Oct 1989). Order Number DE90003948. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Shock-induced reaction synthesis (SRS) is used for solid state processing of Ni-Al, Ni-Si, and Nb-Si type compounds, starting with elemental powder mixtures. The constituent elemental powders are blended in different stoichiometries and packed at 65% density in stainless steel capsules. A steel flyer plate, accelerated by the detonation of an explosive, impacts the powder containing capsules embedded in a steel recovery fixture backed by a momentum trap. The shock wave generated upon impact triggers a self-sustaining, exothermic reaction between the elemental powder constituents, thereby synthesizing the compound and at the same time consolidating the porous mass into 12mm diameter by 5mm thick compacts. The characteristics of the SRS technique and the structural features of the shock synthesized products will be discussed. 18 refs., 11 figs.

7921 (UCRL–21252) **Laterally driven polysilicon resonant microstructures.** Lang, W.C. (California Univ., Berkeley, CA (USA)); Hguyen, Tu-Cuong H.; Howe, R.T. Lawrence Livermore National Lab., CA (USA). 30 Sep 1988. 9p. DOE Contract W-7405-ENG-48. Order Number DE90003930. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Interdigitated finger (comb) structures are demonstrated to be effective for electrostatically exciting the resonance of polysilicon microstructures parallel to the plane of the substrate. Linear plates suspended by a folded-cantilever truss and torsional plates suspended by spiral and serpentine springs are fabricated from a 2 μm-thick phosphorus-doped LPCVD polysilicon film. Resonance is observed visually, with frequencies ranging from 18 kHz to 80 kHz and quality factors from 20 to 130. Simple beam theory is adequate for calculating the resonant frequencies, using a Young's modulus of 140 GPa and neglecting residual strain in the released structures. 24 refs., 9 figs., 2 tabs.

7922 (UCRL–100043) **Brittle to shear grinding mode transition for loose abrasive grinding.** Brown, N.J. (Lawrence Livermore National Lab., CA (USA)); Fuchs, B.A. Lawrence Livermore National Lab., CA (USA). Jul 1988. 15p. Sponsored by U.S. Department of Defense; U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. AFWL-PO-88-088. (CONF-881187–2: Optical fabrication and testing workshop, Santa Clara, CA (USA), 2-4 Nov 1988). Order Number DE90002992. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

SiC, BK-7 and fused silica were abraded with diamond, CBN and B_4C loosely applied. The shear mode behavior is consistent with an elastic penetration model. 7 refs., 2 figs., 6 tabs.

7923 (WSRC-RP–89-476) **Interaction of hydrogen in palladium as prescribed by the embedded atom method.** Wolf, R.J. Westinghouse Savannah River Co., Aiken, SC (USA). [1989]. 14p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. (CONF-891192–24: Annual Westinghouse computer symposium, Pittsburgh, PA (USA), 6-7 Nov 1989). Order Number DE90003893. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The embedded atom method (EAM) is a technique developed at Sandia National Laboratories for the construction of many-body potential models for metals. This description provides a computationally efficient method for the calculation of physical properties of materials. Structural properties for the hydrogen/palladium system were studied as a function of H:Pd stoichiometry and compared to first principle electronic structure calculations. The qualitative behavior is visualized using 3D graphics. 5 refs., 7 figs.

7924 **Materials problem solving with the transmission electron microscope.** Materials Research Society symposia proceedings. Volume 62. Hobbs, L.W.; Westmacott, K.W.; Williams,

D.B. 451p. Materials Research Society, 240 (1986). (CONF-851217–: Materials Research Society meeting, Boston, MA (USA), 2-7 Dec 1985).

These proceedings collect papers from a symposium on materials research with electron microscopy. Topics include: Transmission electron microscopy, microstructural changes, polycrystals, crystal defects, stacking faults, ion implantation, and crystal-phase transformation. Materials studied include: silicon nitrides, silicon carbide, glass, carbon, and nickel, chromium, molybdenum and aluminum alloys.

7925 Tracer diffusion in an ordered alloy: Application of the path probability and Monte Carlo methods. Sato, H. (Purdue Univ., West Lafayette, IN (USA)); Murch, G.E. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 3 (Fal 1984). DOE Contract W-31-109-ENG-38. (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Tracer diffusion in an ordered alloy with nearest neighbor interactions was re-examined with both the Path Probability Method and Monte Carlo Methods. In the case of the Path Probability Method a recent refinement wherein the instantaneous distribution of individual atoms is taken into account in the flow was included. In the case of the Monte Carlo Method special emphasis was placed upon obtaining results of high precision. These developments and results are discussed in detail.

7926 The yield surface of HCP [hexagonal close packed] crystals. Tome, C. (McGill Univ., Montreal (Canada)); Kocks, U.F. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 5 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

A general approach is proposed for calculating the single crystal yield surface (SCYS) of hexagonal close packed (HCP) materials, necessary for the description of the plastic behavior of polycrystals. By taking explicitly into account the symmetry of the deformation systems present in the crystal, a systematic description of the SCYS is obtained. According to this method, the c/a ratio and the critical stresses associated with slip and twinning systems are treated as parameters in the equations that describe the SCYS, which in turn allows for a fully topological characterization of the latter. As an application of the method, the SCYS of materials exhibiting Zr-alloy-type deformation modes is derived and analyzed, and later used for the calculation of textured Zircaloy-2 yield loci.

7927 Investigation of the Cleavage behavior of Cd-doped zinc crystals. Schmitz, H.A. (New York State Univ., Stony Brook (USA)); Bilello, J.C. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 5 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Previous studies of the fracture behavior of Cd-doped zinc crystals had reported an almost ten-fold increase in the effective surface energy upon addition of 0.1 at. % Cd and attributed this result to an increased surface energy. The present work has made systematic measurements of the effective surface energy of the basal plane of zinc for Cd additions of 0.01, 0.03, 0.06, and 0.13 at. % Cd and correlated these findings with observations of the associated microstructure via x-ray diffraction topography. A modified Griffith type analysis, which included appropriate correction for plastic relaxation, was used to evaluate the relative importance of the basal shear stress and the number of dislocations moved as the amount of impurity in the lattice is increased. It is concluded that the increase in fracture toughness with Cd-doping is not dependent upon an increase in the intrinsic surface energy.

7928 The strain, shape and habit of coherent elastic inclusion. Morris, J.W. Jr. (Univ. of California, Berkely (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 5 (Fal 1984). DOE Contract AC03-76SF00098. (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Theoretical work by Eshelby and by Khatchaturyan permits the calculation of the internal strain, the shape, and the habit plane of a coherent inclusion in an elastic matrix. The Khatchaturyan method can be used to show that the asymptotic form of the inclusion is a thin plate with a specific habit plane. The thin-plate habit plane can be found analytically for several combinations of inclusion and matrix symmetries. For thicker particles, the habit plane may change with the particle aspect ratio. The internal strain within the inclusion can also be found analytically in the thin plate limit, in which case the precipitate is necessarily epitaxial in its habit plane. The anisotropy of the strain within the inclusion has the consequence that the apparent symmetry of the inclusion may differ from its symmetry in the relaxed state. These principles are illustrated through examples, including the precipitation of nitrides in ferrite and hydrides in vanadium.

7929 The role of strain and hydrogen on the microstructure of a A-286 iron-base superalloy. Nguyen, D.C. (Carnegie-Mellon Univ., Pittsburgh, PA (USA)); Bernstein, I.M.; Thompson, A.W. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 6 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Specimens with different aging conditions (underage, near-peakage and over-age), deformed either by tension or compression, were characterized by transmission electron microscopy in order to characterize and model the effect of deformation on the loss of coherency or ordered, coherent γ particles. Dark-field micro-graphs appear to show a change in contrast for particles surrounded by dislocation loops. These particles, which are visible in dark field by matrix reflection, disappear in superlattice dark field, which implies that formation of Orowan loops follows or is associated with the loss of coherency of those precipitates. In addition to the above study the effect of a hydrogen aging atmosphere and/or subsequent thermal charging of hydrogen on micro-structural morphology and response to strain is discussed.

7930 Effect of mircrostructure and trapping on the hydrogen embrittlement susceptibility of a titanium - HSLA steel. Stevens, M.F. (Los Alamos National Laboratory, NM (USA)); Bernstein, I.M. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 6 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Hydrogen embrittlement susceptibility of this steel is sensitive to both aging time and temperature, related to the extent of either, or both, Fe_3C and TiC precipitation, as well as metalloid segregation (P and S). The presence of irreversible hydrogen traps was correlated with the presence of fine TiC particles; coarsening of this phase results in a concomitant loss of trapping capacity and a change in embrittlement response. In particular, an improvement in ductility was associated with the formation of fine (20A) clusters of TiC, although concurrent metalloid segregation prevented optimum improvement with aging. Hydrogen-induced crack initiation and growth studies have further suggested that time-lag and breakthrough time hydrogen permeation measurements may scale with threshold and stage II cracking levels respectively. These results will be used to model hydrogen effects in steels of this microstructural type.

7931 Grain size effects on IN903 hydrogen-induced thresholds. Moody, N.R. (Sandia National Laboratories, Livermore, CA (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 7 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Crack growth tests on the fcc superalloy IN903 in 30,000 psi hydrogen, show that hydrogen-induced thresholds increase from 30 to 41 MPa-$m^{\frac{1}{2}}$ as grain size increases from 28 to 130 μm. Threshold decrease when grain size exceeds 130 μm. The threshold values for all grain sizes correspond to a yield strength of 1068 MPa. As previous tests on IN903 show, thresholds determined at hydrogen pressures greater than 15,000 psi are independent of hydrogen pressure and suggest that the grain boundaries are effectively saturated with hydrogen. The constant yield strength and effective grain boundary hydrogen concentration permit analysis of threshold fracture behavior in terms of grain size and grain boundary microstructure. The relationship of these microstructural parameters to fracture process zone size and the stress intensity required for crack nucleation shows that grain size effects on thresholds can be explained by geometrical considerations.

7932 Oxidation and oxidation/sulfidation of chromium and iron-chromium alloys. Yurek, G.J. (Massachusetts Institute of Technology, Cambridge (USA)); LaBranche, M.; Kim, Y.; Uhlig, H.H. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 9 (Fal

1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Pure Cr and a binary Fe-25 wt% Cr alloy develop protective Cr_2O_3 scales on their surfaces in H_2-H_2O gas mixtures at 900C; i.e., the kinetics obey a rate law of the form $(\Delta m/A)^n = kt$ with $n > 2$. The addition of H_2S to the gas mixture causes an increase in the rate of scaling unless the H_2O/H_2S ratio in the gas phase exceeds a critical value. Scales comprising both sulfides and oxides form when the H_2O/H_2S ratio is less than the critical value, which is higher for the Fe-Cr binary alloy than for pure Cr. Preoxidation before exposure to a gas mixture with a H_2O/H_2S ratio less than the critical value delays, but does not prevent rapid scaling; i.e., the preformed Cr_2O_3 scales eventually breakdown and are replaced by rapid-growing scales comprising oxides and sulfides. The mechanisms of the oxidation/sulfidation processes are described and the existence of the critical H_2O/H_2S ratios are explained.

7933 Influence of oxygen and chlorine potentials on high temperature corrosion behavior of materials. McNallan, M.J. (Univ. of Illinois, Chicago (USA)); Liang, W.W. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 9 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Oxygen is the most common oxidizing species in the environment, and both metals and non-oxide ceramics are subject to corrosion by formation of oxides at high enough temperatures. When chlorine is also present, high temperature corrosion is complicated by the volatility of chloride and oxychloride reaction products. Depending on the particular conditions of the corrosion, the corrosion may occur by the formation of volatile corrosion products, condensed corrosion products, or a combination of the two. In an industrial process, the kinetics of a corrosion process may change drastically when small changes in the environment produce changes in the nature of the corrosion products. Examples of both calculated and observed changes in corrosion behavior in environments containing both oxygen and chlorine are presented.

7934 Titanium-potassium heat pipe corrosion studies. Lundberg, L.B. (Los Alamos National Laboratory, NM (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 10 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Titanium heat pipes with potassium as the working fluid are being considered for use in waste heat radiators for space nuclear power systems, and because they are required to operate with low probability of failure for long periods of time, it is essential to know their resistance to corrosion failure. Corrosion in heat pipes is caused either by dissolution of the container tube in the condenser by simple solution in the working fluid or attack of the evaporator by impurity generated corrosive compounds. An experimental study of the susceptibility of wickless titanium-potassium heat pipes to corrosive attack was conducted in vacuo at temperatures at 900 K and for periods up to 4797 h without failure. An attempt was made to accelerate the corrosion by concentrating both the input and output heat flux. Some movement of carbon, nitrogen, and oxygen was observed in the titanium container tube, and this caused expected changes in the microstructure. The lack of significant corrosion refuted previous reports of attack of titanium by potassium, and it did not contradict our own predictions that were based on thermochemical consideration of the expected heat pipe corrosion mechanisms.

7935 In situ studies of crack tip deformation processes and the effects of hydrogen on these processes. Robertson, I.M. (Univ. of Illinois, Urbana (USA)); Birnbaum, H.K. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 10 (Fal 1984). DOE Contract AC02-76ER01198. (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The technique of in situ stressing in an environmental cell in the TEM has been applied to examine the crack tip processes during fracture of a number of metals and alloys and to study the effects of gaseous H_2 on these processes. These observations were correlated with studies carried out on macroscopic specimens using in situ fracture in the SEM and other techniques to establish the relationships between microscopic and macroscopic observations. In the present paper the authors describe the techniques used for Mode I in situ fracture studies and some of the observations made on the behavior of Ni and its alloys. The dislocation structures formed at the tips of the crack and the dynamic processes by which the fracture propagates are described. The effects of hydrogen on the crack tip deformation and fracture are described.

7936 HVEM in situ studies of strain localization in Al-Li alloys. Kenik, E.A. (Oak Ridge National Laboratory, TN (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 11 (Fal 1984). DOE Contract W-7405-ENG-26. (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Aluminum-lithium alloys are attractive on strength/weight and strength/modulus bases. However, in the hardened state, these alloys exhibit embrittlement and intergranular failure. Precipitate free zones (PFZs) at grain boundaries are generally blamed for the poor mechanical properties. In situ deformation studies in an HVEM permit the observation of dislocation motion in the matrix and the PFZ. Strain localization in both regions has been studied. Dislocations from shear bands enter the PFZs and cross-slip along the PFZ, trailing segments pinned at the PFZ-matrix boundary. Successive dislocations produce a dislocation wall at this boundary with significant misorientation (~10°) between the matrix and its PFZ. Other microstructural observations of strain localization and their relation to embrittlement of A1-Li alloys are discussed.

7937 Physico-chemical processes in shock compression of powders. Graham, R.A. (Sandia National Laboratories, Albuquerque, NM (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 12 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Descriptions of shock-compression processes in low density powder compacts are basic to dynamic compaction undertaken to form near-net shape parts and for modification of powders to either alter their physical properties or change their response to post-shock processing. Nevertheless, there is little detailed information on shock compression of powders and little basic research in progress. The present review of the status of descriptions of the shock-compression process rests upon original studies of inorganic powders and on earlier data on metallic powders. A critical analysis of models currently proposed to describe interparticle bonding on the basis of localized surface heating is based on all available data. It is suggested that the interparticle bonding process is the most crucial area for research.

7938 Shock consolidation of rapidly solidified type 304 stainless steel powders. Flinn, J.E. (EG & G Idaho, Inc., Idaho Falls, ID (USA)); Korth, G.E.; Graham, R.A.; Green, R.C.; Schoenlein, L.H. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 12 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Shock compaction of dissolved gas (DGA) and centrifugal atomized (CA) Type 304 SS powders have been assessed using explosive techniques. The goal of the study is to produce full dense crack free monoliths for structure/property correlations, retaining the unique microstructural features afforded by RSP. Peak shock pressures range from 5 to 30 GPa, and fully dense compacts have been produced at the high pressures using die/target, punch, and flyer plate configurations. Microstructural assessments show four morphologies: (1) A thin brittle zone (back surface of the compact) associated with cold welded particles; (2) Zone of extensive plastic deformation with fuse-bonded particles (bulk of compact); (3) Region of massive particle extrusion; and (4) Areas of recrystallization/melting. Characterization of preshocked and consolidated powders include optical and electron microscopy, STEM, and microhardness and DSC measurements.

7939 Effect of powder particle size and shock stress on dynamically compacted powder microstructures. Smugeresky, J.E. (Sandia National Laboratories, Albuquerque, NM (USA)); Gourdin, W.H. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 13 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Rapidly solidified Al-Si powders of several particle size distributions were dynamically compacted for shock stresses in the range of 1 to 4 GPa. Both gas gun and explosive compaction techniques were used and variations in compaction fixturing were explored. The experimental conditions were chosen on the basis of the flux model

for energy deposition. The microstructural features developed during compaction was in reasonable agreement with the model and a substantial reduction in the extent of cracking can be realized. The nature of the interfaces between the unmodified powder microstructure and the regions modified during compaction is presented.

7940 Influence of small yttrium additions on the oxidation of nickel and on grain boundary diffusion in NiO. Moosa, A.A. (Argonne National Laboratory, IL (USA)); Rothman, S.J.; Nowicki, L.J. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 13 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The oxidation of Ni-0.1 wt.% alloy in the temperature range 500-900 C was measured by the weight gain technique, and grain-boundary diffusion on the resulting Y doped NiO foils was measured by tracer-sectioning. The Y additions do not affect the diffusion of Ni in NiO but decrease the oxidation rate of Ni above 700 C, apparently by increasing the grain size of the NiO films.

7941 Platelet mechanism of erosion model. Levy, A.V. (Lawrence Berkeley Laboratory, CA (USA)); Humphrey, J.A.C.; Azzola, J. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 13 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The platelet mechanism of erosion was used as the basis for an analytical model to predict erosion rates of ductile metals. The model was based on an energy balance where the kinetic energy of the impacting particles was set equal to the several elements of the erosion mechanism that consumed that energy. Among the elements considered were extrusion and forging of platelets, cold working of the substrate, heating of the surface by adiabatic deformation and friction, fracture of platelets and rebound energy of the particles. The development of the model and its experimental verification are discussed.

7942 Elevated temperature erosion of heat treated alloys. Levy, A.V. (Lawrence Berkeley Laboratory, CA (USA)); Yan, J. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 13 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The erosion of heat treated alloys in the range of their heat treatment temperatures was investigated. Alloys were tested that had sufficient elevated temperature corrosion resistance to not oxidize in the test temperature-time cycle. Al_2O_3 erodent particles were carried in a nitrogen gas stream, impinging on specimens at angles of 30° and 90° and 30 m/s velocity located at a distance of 1.25 cm from the nozzle exit. The effect of erosion test temperature on the erosion rates of the alloys in their solid solution, tempered and precipitation hardening ranges was determined. The eroded surfaces and cross sections were studied metallographically to determine what morphological modifications to the as-heat treated structures had occurred as the result of the erosion process.

7943 In-situ straining of CU-10Ni-6Sn spinodal alloy in HVEM. Lee, Tong C. (Michigan State Univ., East Lansing (USA)); Shekhar, S.; Subramanian, K.N. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 18 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Cu-10Ni-6Sn spinodal alloy specimens aged for various lengths of time at 350 C were strained in-situ in High Voltage Electron Microscope. Dislocation motion and its change of character during its motion were recorded on video tapes. Mode of crack propagation was also studied in these experiments. Dynamic events observed during these studies are discussed using a video presentation of the results obtained.

7944 Stress corrosion cracking of beta brass in aqueous environments. Blanchard, W.K. Jr. (Michigan Technological Univ., Houghton (USA)); Hintz, M.B.; Heldt, L.A. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 19 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Beta brass is extremely susceptible to stress corrosion cracking in aqueous environments. Depending upon the mechanical and electrochemical conditions, cracking follows wither an intergranular or transgranular path. The effects of the local stress and chemical environment on cracking susceptibility are described and discussed.

7945 Surface chemistry near stress corrosion crack tips in copper single crystals. Brindley, P.K., Hintz, M.B. (Michigan Technological Univ., Houghton (USA)); Heldt, L.A. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 19 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Scanning Auger spectrometry was employed to determine the surface chemistry near the tips of stress corrosion cracks in copper single crystals. Cracks occurring at controlled electrochemical potentials in sodium nitrite solutions have high surface concentrations of oxygen extending to the leading edge of the crack. The thickness of the oxygen rich layer was examined by removing successive surface layers by inert ion sputtering. The results are compared to those obtained for copper-zinc alloys and are discussed in terms of plausible stress corrosion mechanisms.

7946 Plastic zone size and sample thickness effects on the intergranular subcritical crack growth of iron and nickel. Jones, R.H. (Pacific Northwest Laboratory, Richland, WA (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 19 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Intergranular subcritical crack growth rate measurements have been made on iron and nickel samples at cathodic potentials in 1N H_2SO_4 at 25 C. Samples with thicknesses of 2.5 mm, 5 mm and 10 mm were tested. Grain boundary sulfur concentrations as measured by Auger Electron Spectroscopy were about 0.3 monolayers in both iron and nickel. Plastic zone sizes were determined by electron channeling pattern analysis and microhardness and were dependent on thickness. Subcritical intergranular crack growth measurements at cathodic potentials showed that iron and nickel have similar values of K_{TH}, comparable crack growth rates and a similar decrease in K_{TH} with increasing sample thickness. The similarities and differences in the subcritical crack growth behavior of iron and nickel are discussed in the context of various hydrogen embrittlement mechanisms.

7947 Mechanisms of hydrogen attack of carbon and 2-1/4 Cr-1Mo steels. Parthasarathy, T.A. (Ohio State Univ., Columbus (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 19 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Dilatometric studies have shown that the Hydrogen Attack (HA) rates of 2-1/4 Cr-1 Mo steels are three to four orders of magnitude slower than those of carbon steels. In this presentation, the differences in the HA behavior are explained as due to differences in bubble densities between the steels. Using a model incorporating grain boundary diffusion, surface diffusion, and power law creep as the bubble growth mechanisms, bubble growth regime maps drawn for steels of different bubble densities and carbon activities are presented.

7948 Effects of laser processed surfaces in sliding wear. Caldwell, S.G. (Vanderbilt Univ., Nashville, TN (USA)); Wert, J.J. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 19 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Numerous studies in the past decade have confirmed the importance of near-surface microstructure to the sliding wear process. Laser processing of contact surfaces provides a convenient and effective method of producing a thin surface layer of highly refined structure while maintaining essentially the same composition as the bulk material. Laser modified surfaces are used to simulate preexistent transfer layers in this study. Common alloys such as 1100 aluminum and OFHC copper have been worn in a variety of unlubricated sliding tests. Standard metallographic techniques have been employed to characterize the effects of a preexistent uniform layer of extremely fine structure relative to the behavior of annealed surfaces.

7949 Elevated temperature backstresses and the dislocation microstructure in type 304 stainless steel. Kassner, M.E. (Lawrence Livermore National Lab., CA (USA)); Miller, A.K. *TMS*

(The Metallurgical Society) Paper Selection (USA), 56: 21 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

This investigation studied the relationship between the dislocation microstructure and the backstress in type 304 stainless steel deformed at 750 and 850 C (~ 0.6 and 0.7 Tm), at a strain-rate of 4.0 × 10^{-4} s^{-1}. Hollow torsion specimens were deformed to various transient strains between 0.05 and 0.45 at these conditions. Bauschinger effect tests were performed within this strain regime. Backstresses were calculated from these tests. Solid torsion specimens were deformed at the same temperature-strain rate combination as the hollowed (Bauschinger effect test) specimens. The solid specimens were quenched at strains identical to those at which Bauschinger effect tests were performed on the hollow specimens. The microstructures of the quenched specimens were examined by TEM. The correlation between the backstress and the microstructure revealed that the backstress or kinematic hardening in 304 stainless steel, at these temperatures, does not (in contrast to other investigations) appear to be strongly dependent on the microstructural heterogeneity provided by subgrain or cell boundaries.

7950 Effect of thermal and strain history on the high temperature mechanical behavior of two ferritic stainless steels. Chen, S.H. (Northwestern Univ., Evanston, IL (USA)); Kim, S.; Weertman, J.R. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 21-22 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The effect of aging on the subsequent high temperature fatigue life has been investigated for two ferritic stainless steels: Fe9CrlMo+V,Nb and Fel2CrlMo. Fatigue life has been measured in material aged 5000 h at 593 C, then fatigued at the same temperature in strain control, with and without hold periods. At least for the test conditions studied, the introduction of the aging period did not appreciably alter the cycles to failure from the values found in steel given only the standard normalizing and tempering treatment. However, the corresponding stress amplitudes were markedly decreased. The effect of aging and of brief periods of high temperature fatigue on creep strength have been measured and are discussed.

7951 Microstructures in rapidly solidified heat treated Ti-Si alloys. Chumbley, L.S. (Univ. of Illinois, Urbana (USA)); Fraser, H.L.; Muddle, B.C. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 24 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Rapidly solidified alloys were produced using laser surface melting and melt spinning techniques. The microstructures have been fully characterized using analytical transmission electron microscopy for both the as-solidified condition and after subsequent heat treatment. Previously unreported phases have been identified in the rapidly solidified material.

7952 Rapid solidification of aluminum 2 weight percent beryllium: A microstructural comparison of laser surface treated and melt spun ribbon. Van Aken, D.C. (Univ. of Illinois, Urbana (USA)); Fraser, H.L. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 24 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The precipitation behavior of a hypereutectic aluminum-beryllium alloy is examined. The beryllium precipitates exhibit several crystallographic orientations all having the beryllium hexagonal crystal structure. The precipitates are 50 to 100 angstroms in size. Good thermal stability was observed up to 400 C. A comparison of cellular and plane-front solidification is also presented.

7953 Phase transformation induced by cracking and other stress concentrations. Li, J.C.M. (Univ. of Rochester, NY (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 27 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Since the local stresses may reach very high values near a crack tip or other stress concentrations, stress induced phase transformation (including twinning, precipitation, void formation, cracking, etc.) could take place at these locations and the result would be to reduce these stress concentrations. Some examples are given. The effect of such stress-induced phase transformations on the stress intensity factor at the crack tip is discussed. An energy balance showed that the fracture toughness increases with the stress-induced phase transformation similar to crack tip plasticity or any other effects associated with crack extension.

7954 In-situ high-voltage electron microscopy (HVEM) studies of radiation-induced phase transformations. Okamoto, P.R. (Argonne National Lab., IL (USA)); Lam, N.Q.; Averbach, R.S.; Rehn, L.E. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 30 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

In situ study of radiation effects in materials has been a major use of the HVEM. The ANL HVEM-Tandem Accelerator Facility equipped with an ion beam interface fully exploits in the in situ irradiation capabilities of the HVEM and greatly extends the range of nonequilibrium irradiation phenomena that can be investigated. Direct observation of microstructural changes is possible from 10 to 1000K under carefully controlled irradiation conditions for a wide range of charged-particle masses and energies. Selected examples of current research are discussed. The unique advantages and limitations of the HVEM for investigation radiation-driven phase changes are clearly illustrated by complementary HVEM and Rutherford backscattering studies of radiation-induced segregation and ion beam mixing.

7955 TEM studies of crack tip deformation in bcc metals at low temperatures. Park, C.G. (Oak Ridge National Laboratory, TN (USA)); Ohr, S.M. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 31 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Electron microscope studies have been made of the nucleation and propagation of cracks in bcc metals during in situ tensile deformation at low temperatures. A low temperature tensile specimen stage capable of operating down to liquid nitrogen temperature has been built for this experiment. The temperature dependence of crack tip deformation and its relationship to the ductile-brittle transition have been studied by determining the distribution of dislocations ahead of propagating cracks. The observed slip systems have been analyzed in terms of the resolved shear stress modified by the presence of the crack. The results are compared with the data obtained from tensile tests performed on bulk specimens at low temperatures.

7956 Stress corrosion cracking study of amorphous stainless steel. Jones, R.H. (Pacific Northwest Laboratory, Richland, WA (USA)); Wang, R.W. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 36 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The stress corrosion cracking resistance of amorphous stainless steel was found to be equal to or better than wrought low carbon type 304SS when tested in $MgCl_2$ at 155 C. Amorphous stainless steel samples with chemical composition of Fe+18Cr+8Ni+18W were produced by sputter deposition. Bend tests were conducted on 0.25 to 0.5 mm thick samples of amorphous stainless steel, low carbon 304SS and sensitized high carbon 304SS in boiling $MgCl_2$. The sample load was monitored versus time and the time to failure versus maximum tensile stress was determined. These results indicate that a glassy stainless steel coating applied for its corrosion resistance would also not fracture and allow substrate corrosion at stresses equal to the substrate stress.

7957 Radiation damage in amorphous solids - a computer simulation. Chaki, T.K. (Univ. of Rochester, NY (USA)); Li, J.C.M. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 36 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

It is known for crystalline materials that injection of high energy atoms introduces point defects. The nature of defects is not known for amorphous solids. So a molecular dynamic simulation of radiation damage in an amorphous metal was carried out. An amorphous structure of 685 atoms with periodic boundary conditions in all 3 dimensions was equilibrated first. Then one atom on the surface was given a high initial velocity so it was injected inward. Radial temperature distribution around the line of injection was calculated as a function of time. Void distribution and its evolution with time in the direction of injection was calculated by counting the atomic centers in thin slabs perpendicular to the line of injection. The swelling of

the whole solid was calculated also. Some results are compared with experiments.

7958 Diffusion-limited-evaporation: The effect of a concentration dependent diffusion coefficient. Murch, G.E. (Argonne National Laboratory, IL (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 36 (Fal 1984). DOE Contract W-31-109-ENG-38. (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The phenomenon of diffusion-limited-evaporation is discussed with emphasis on its description using the diffusion equation. When the diffusion coefficient is a function of concentration of the evaporating species, which is usually the case, the diffusion equation is not, in general, amenable to analytical solution. A new and powerful Monte Carlo Method developed by the author is described and applied to the problem. Example results are given for several functional forms of the concentration dependence of the diffusion coefficient and boundary conditions of the system.

7959 Diffusion of ^{60}Co in $(Co_{0.8}Fe_{0.2})_3$ V alloys in the ordered and disordered states. Mantl, S. (Argonne National Laboratory, IL (USA)); Rothman, S.J.; Nowicki, L.J.; Braski, D. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 36 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The diffusion of ^{60}Co has been measured in $(Co_{0.8}Fe_{0.2})_3$ V alloys above and below the critical temperature for ordering. Above T_c, normal diffusion kinetics are observed with D in cm^2/s given by 10.5 exp(- 3.24 eV/kT). For samples annealed below T_c the ^{60}Co depth profiles are unusual, only approximate values of D are obtained, and mass transport along the grain boundaries is observed.

7960 Diffusivity of oxygen in solid nickel. Park, J.W. (Univ. of Illinois, Urbana (USA)); Altstetter, C.J. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 36 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The diffusion behavior of oxygen in solid nickel has been investigated in the temperature range 800 to 1200 C utilizing a double galvanic cell. The oxygen potential in nickel was fixed by applying a constant voltage to one cell, while the oxygen diffusivity was obtained from the change of the electromotive force with time at the other cell. A potentiostatic technique was also employed to determine the diffusivity as well as the solubility of oxygen in solid nickel. The standard thermodynamic functions for oxygen solution in nickel are obtained from the solubility data.

7961 Diffusion and trapping of oxygen in Nb-V alloys. Park, J.W. (Univ. of Illinois, Urbana (USA)); Altstetter, C.J. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 37 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The diffusion coefficient of oxygen has been measured in Nb-V alloys across the entire range of Nb/V concentrations. Measurements were made using a solid state electrolytic cell technique over the temperature range 650-1100 C. The increase in the activation energy for oxygen diffusion in the alloys was interpreted as being due to trapping of oxygen atoms by the substitutional solute atoms. The substitutional-interstitial interaction behavior over the entire composition range is discussed in terms of chemical affinity and atomic size mismatch.

7962 Thermotransport of hydrogen in niobium and tantalum at higher hydrogen concentrations. Peterson, D.T. (Iowa State Univ., Ames (USA)); Kim, S.J. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 37 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Measurements of thermotransport of hydrogen in niobium and tantalum at high hydrogen concentrations can be interpreted by two different phenomonological equations and heats of transport. Atomistic interpretations of these heats of transport are complicated by a nonconstant activity coefficient that should also involve an atomistic interpretation. Comparison is made with changes in the thermoelectric power of the hydrogen-containing solid solutions.

7963 Solution hardening. Kocks, U.F. (Los Alamos National Laboratory, NM (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 39 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The effect of solutes on the yield stress has been described by two kinds of models: in one, the solute atoms are treated as discrete obstacles, or clusters of obstacles, to dislocation motion; in the other kind, their effect is smeared out in various ways. Thermal-activation analysis is used to show that the discrete-obstacle model is in qualitative and quantitative disagreement with a variety of experimental facts. On the other hand, all facts can be at least qualitatively explained if one assumes that solute atoms act as if they were smeared out along the dislocation line. Such a model also allows a continuous transition to the regime of dislocation locking by strain aging, which dominates solution hardening at elevated temperatures. Finally, the significant influence of solutes on strain hardening is discussed.

7964 Relationship between furnace voltage signatures and the operational parameters arc power, CO pressure, and electrode gap during vacuum arc melting Inconel 718. Zanner, F.J. (Sandia National Labs, Albuquerque, NM (USA)); Bertram, L.A.; Harrison, R.; Adasczik, C. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 40 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Statistically designed experiments were conducted at two different production melt shops to evaluate the influence of arc power, CO pressure, and electrode gap on drop short and anode spike frequency. Approximately 11,000 kg of Inconel 718 alloy 0.4 m diameter electrodes were vacuum arc remelted into 0.5 m diameter ingots. Analyses of the experimental results produced regression models which show that the frequency of these events is inversely proportional to power, CO pressure, and gap. The inverse nature of this relationship is created by the behavior of the cathode spots and fluid mechanics of the liquid metal columns. Residuals generated by the models were analyzed with a matrix technique and the resulting error band indicates that the models are stable for control purposes.

7965 Effect of temperature on the dislocation structures in polycrystalline Ni_3Al. Baker, I. (Dartmouth College, Hanover, NH (USA)); Schulson, E.M. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 41 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The dislocation structures present in polycrystalline Ni_3Al of stoichiometric composition strained under tension at 10^{-4} s^{-1} at temperatures from 77K to 1023K have been characterized using transmission electron microscopy. At all temperatures examined dislocations had line directions closely parallel to <110>. For temperatures up to 673K both APB-coupled dislocation pairs and S-ISF coupled dislocation pairs were common. Jogs on dislocations were frequent and faulted dislocation loops were observed. At temperatures above 873K trace analysis of dislocation pile-ups indicated that slip occurred mostly on cube planes. At these higher temperatures S-ISF pairs were rare and faulted dislocation debris was absent. Rows of perfect dislocation loops were common and evidence was found which indicated that these formed by the collapse of near-edge dipoles. Dislocation networks were also observed.

7966 Effects of grain size on the strength and ductility of Ni_3Al and Ni_3Al + boron. Viens, D.V. (Dartmouth College, Hanover, NH (USA)); Weihs, T.P.; Baker, I.; Schulson, E.M. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 41 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Tensile and compression experiments have been performed on Ni_3Al and on Ni_3Al + B at 77K to 1023K at $1 \times 10^{-4}s^{-1}$. At low temperatures yielding occurs discontinuously and the yield strength obeys the relationship $\sigma_y = \sigma_i + kd^{-3/4}$ where σ_i and k are constants. Grain refinement has little effect on the ductility of the binary alloy, but leads to a brittle to ductile transition in the alloy containing boron. At high temperatures, grain refinement weakens the material, owing to grain boundary sliding. Dynamic recrystalization occurs and leads to another brittle to ductile transition upon refining the

grains. Under all conditions investigated, fracture occurs intergranularly. An analysis based upon a work-hardening model is given for the $d^{-3/4}$ dependence of the yield strength at low temperatures.

7967 **Modeling chromium depletion in Ni-Cr-Fe alloys.** Was, G.S. (Univ. of Michigan, Ann Arbor (USA)); Kruger, R.M. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 42 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Thermodynamic and kinetic models are constructed to describe the development of the chromium depleted zone in Ni-Cr-Fe alloys heated in the range 773 K to 1173 K. The thermodynamic model provides the chromium concentration at the carbide-matrix interface as a function of alloy composition and temperature. The kinetic model tracks the shape of the chromium profile as a function of time at temperature and grain size. Measured results obtained via STEM, agree well with model results for the dependence of chromium depletion on the various input parameters as well as the magnitude and shape of the chromium depleted zone. Results confirm that carbide precipitation at the grain boundaries is controlled by volume diffusion of chromium in the matrix and that in the temperature range 873 K to 1073 K the chromium concentration in the grain boundary accurately approximates the carbide-matrix interfacial concentration.

7968 **Effect of microstructure on the fatigue behavior of dual phase steels.** Ramage, R.M. (Univ. of Virginia, Charlottesville (USA)); Shiflet, G.J.; Jata, K.V.; Starke, E.A. Jr. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 47 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Inexpensive, low-alloy steels are used in a variety of applications, many of which involve cyclic loading. Dual-phase steels are of special interest to the automotive industry and have the attractive feature that both strength and ductility can be increased simultaneously by selective control of the microstructure. The monotonic and cyclic deformation behavior and LCF performance of two microstructural variants of a dual-phase Fe-C-Mn steel were investigated. One consisted of a continuous soft phase (ferrite) surrounding a hard phase (martensite) and the other consisted of the hard phase surrounding the soft phase. The effect of these microstructural variants on deformation behavior, cyclic stress-strain response and fatigue crack initiation resistance is discussed.

7969 **Dislocations in amorphous metals.** Li., J.C.M. (Univ. of Rochester, NY (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 48 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The question whether line defects such as dislocations can be created and stabilized in amorphous metals is discussed in three aspects: The first is a general discussion of existence, identification and stability including a generalized Burgers circuit and a Burgers vector distribution. The second is a collection of indirect evidences from the properties of shear bands such as the displacement distribution, the reverse shear behavior, the effect of annealing and the intersection between shear bands. The third is a series of computer simulation experiments including the stability under relaxation, the minimum displacement vector needed for creation and the motion characteristics under stress.

7970 **Microstructure formation and solute partitioning during intercritical annealing of dual phase steels.** Ohmura, M. (Univ. of California, Berkeley (USA)); Thomas, G. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 50 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Microstructure formation and solute partitioning depend on prior microstructure, intercritical annealing conditions, and alloy composition. In this research the following alloys: Fe-1.5%Mn-0.1%C, Fe-2%Si-0.1%C, and Fe-1%A1-0.1%C were studied. The starting condition was as quenched lath martensite from which annealing in the ferrite+austenite region was followed by water quenching. The concentration of substitutional elements in both ferrite and martensite were measured as a function of annealing times and temperatures by using microanalysis STEM-EDX methods. The results indicate that austenite growth and microstructure formation were more controlled by substitutional element in the case of Mn steel than that of Si steel. Microstructure formation mechanism and effect of alloy elements on solute partitioning are discussed.

7971 **Microstructure studies of dynamically compacted material.** Miller, D.J. (Univ. of Illinois, Urbana (USA)); Konitzer, D.G.; Fraser, H.L. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 51 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Dynamic compaction has been used successfully to compact aluminum and titanium powder. A light gas (helium) gun was used for these studies. Fine oxide powders were added to the metal powders to identify the interparticle boundaries in the compacted material. The as-compacted and heat treated microstructures, particularly the interparticle boundary region, were examined by TEM and optical microscopy. These results and preliminary mechanical test results are presented.

7972 **Experimental techniques used to determine the yield locus of 1100 aluminum tubes.** Aikin, R.M. (Los Alamos National Laboratory, NM (USA)); Stout, M.G.; Helling, D.E. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 53 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The experimental techniques needed to prestrain tubes and subsequently determine the yield locus are out of the ordinary. Tubes were deformed in combinations of tension and torsion using an MTS servo-hydraulic system with special modifications to facilitate extremely accurate control and strain measurement. The MTS test system, these modifications, and our general approach to instrumentation are discussed. Accurate alignment of test fixtures and use of lubricated mandrels was necessary to prevent the buckling of the tubular test specimens under torsional prestraining. A technique which permitted a torsional prestrain to $\gamma = 0.5$ is described and a general description of subsequent yield loci experiments given.

7973 **Yield loci of 1100 aluminum after various prestrains.** Helling, D.E. (Stanford Univ., CA (USA)); Miller, A.K.; Aikin, R.M.; Stout, M.G. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 53 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

1100 aluminum tubes have been prestrained to an effective strain of 0.035 in different combinations of tension and torsion loading. Subsequent to prestraining the yield loci, defined by 5×10^{-6} offset were determined. The authors found that this small strain yield locus develops a rounded corner in the direction of prestrain while opposite the prestrain it flattens, for proportional loading paths. Tubes were also prestrained to the same point in stress space by three different paths, pure tension followed by pure torsion, pure torsion following by pure tension and a proportional ratio of tension and torsion. For these three paths the subsequent yield loci were identical, indicating path independence. Finally these experimental results have been described in terms of an expansion, a translation and a distortion of the original yield locus.

7974 **Comparison of tension and torsion data for a variety of FCC metals.** Stout, M.G. (Los Alamos National Laboratory, NM (USA)); Aikin, R.M. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 53 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Constant true strain rate compression data have been taken for 1100 aluminum, 99.999% pure aluminum, OFE copper and 70-30 brass. The materials were tested to a strain of 2.0 by use of a remachining technique. The authors found a continuously hardening stress-strain curve, consistent with literature data for all the materials. The texture which was measured at strains of 1.0 and 2.0 for OFE copper was a [110] fiber. These compression data were compared to torsion data for the same material using a von Mises equivalent stress-strain criterion. In all cases the torsion data lies well below that from compression. Possible use of a crystallographic based equivalent stress-strain criterion is discussed.

7975 **Effects of strain aging on homogeneous plastic deformation properties of aluminum and an aluminum-magnesium alloy.** Kuo, R.C. (Cornell Univ., Ithaca, NY (USA)); Henderson, D.W.; Li, C.Y. *TMS (The Metallurgical Society) Paper Selection*

(USA), 56: 53 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The phenomenon of strain aging is examined in aluminum and in an aluminum-1% magnesium alloy. Time dependent strain aging effects on homogeneous plastic deformation properties have been characterized by direct mechanical measurement. The applicability of a state variable description of these strain aging effects is examined.

7976 Effect of strain rate on the deformation and fracture behavior of ductile metals containing porosity. Magnusen, P.E. (Michigan Technological Univ., Houghton (USA)); Follansbee, P.S.; Koss, D.A. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 54 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The influence of strain rate on the tensile deformation and fracture behavior of powder-fabricated titanium and nickel containing porosity has been investigated. Measurements of uniform strains, local fracture strains, and elongations to failure show that, over the range of strain rates from 10^{-4} to 10^{2} s^{-1}, there is little or no effect of the strain rate on the fracture behavior of these materials at any of the porosity levels studied. A slight elongation minimum in the two lowest porosity levels for titanium occurs at intermediate strain rates and is interpreted to be due to thermal gradients forming during deformation.

7977 Electron microscopic observations of the dislocation substructure in niobium - 10 at.% vanadium alloy. Jagannadham, K. (Ames Laboratory, IA (USA)); Laabs, F.C. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 57 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The development of dislocation substructure in deformed Niobium - 10 at.% Vanadium alloy with and without Hydrogen is described as a function of Hydrogen concentration, temperature of deformation and grain size of the material. Further, observations of crack propagation in this alloy in-situ in a tensile stage are presented to show the possible influence of Hydrogen on embrittlement.

7978 Deformation and fracture behavior of niobium - 10 at.% vanadium alloy. Jagannadham, K. (Ames Laboratory, IA (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 57 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The deformation and fracture behavior of Niobium - 10 at.% Vanadium alloy with 200 ppm wt% Hydrogen and without Hydrogen subjected to tensile deformation are presented. The slip vs. twinning mode of deformation in single crystals and big grain size polycrystals as a function of orientation, temperature of deformation and surface condition in this alloy in the presence of Hydrogen is described in detail. The cleavage planes exhibited by this alloy along with the fracture surface observations are described to show the effect of Hydrogen in the embrittlement of this alloy.

7979 Effect of oxygen on mechanical properties of Nb-V alloy. Carlson, O.N. (Iowa State Univ., Ames (USA)); Indrawirawan, H. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 57 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The results of a study of the effect of oxygen on the mechanical properties of a Nb-10 at.% V alloy are described. The effect of oxygen on the tensile yield strength, ductility and strain rate sensitivity were determined as a function of temperature for the range of 78 to 300 K. The effect of vanadium on the oxygen Snoek peak in niobium was determined as a function of vanadium concentration. It was observed that the addition of up to 10 at .% vanadium shifts the oxygen peak temperature upward about 80 K. The activation energy for relaxation of oxygen increases from 108.8 KJ/mole for pure niobium to 154 KJ/mole for 2.5 at.% V and to 200 KJ/mole for 10 at.% V. A possible interpretation of these observations is presented in terms of a substitutional - interstitial solute interaction.

7980 Anisotropic multi-axial properties of rolled sheet. Canova, G.R. (Los Alamos National Laboratory, NM (USA)); Kocks, U.F.; Hecker, S.S.; Stout, M.G. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 60 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

A computer simulation of polycrystal deformation has been used to predict the properties of rolled sheet under subsequent stressing. In particular, the yield stresses and r-values for tension in different directions in the sheet have been derived on the basis of deformation textures. The predicted yield surfaces of textured sheets have sharp ridges; the implications of this for the development of localized necks under biaxial stretching are explored. Some rolled sheets of nickel have been welded into tubes and tested under multi-axial stresses. Results are compared with predictions.

7981 Hydrogen attack in Cr-Mo steels. Ruoff, S. (Cornell Univ., Ithaca, NY (USA)); Stone, D.; Wanagel, J.; Li, C.Y. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 61 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Experiments conducted upon 3Cr-1.5Mo steel at elevated temperatures (600 C), and high pressure hydrogen (2000 psi), have shown a greater resistence to hydrogen attack compared with similar studies of 2.25Cr-lMo steels. Hydrogen exposure tests with and without an applied stress have been performed on both types of steels. Results of similar conditions show clear evidence of hydrogen attack in 2.25Cr-lMo steel, however, for the 3Cr-1.5Mo steel with exposure time up to 80 days without an applied stress no evidence of hydrogen attack is observed. For stress-rupture tests using stresses of 14 and 16 ksi, the 3Cr-1.5Mo steel showed no effects of hydrogen attack, and no damage was observed using a SEM.

7982 Observations of plastic behavior in hydrogenated Ni single crystals. Hintz, M.B. (Michigan Technological Univ., Houghton (USA)); Koss, D.A.; Heldt, L.A. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 62 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

One millimeter thick sheet tensile specimens have been fabricated from Ni single crystals. 0.5 mm square grids have been etched into one side of the approximately 12 mm x 3 mm gauge sections to allow local strain determinations subsequent to testing. After masking all but a 1 mm length of the gauge section to avoid solution exposure, the specimens were strained at constant extension rate in 1 N H_2SO_4 under hydrogen evolution conditions. The local strains and slip traces in the exposed and unexposed regions of the gauge sections are compared and discussed.

7983 Inclined dislocation emission versus brittle extension at crack tip. Chang, S.J. (Oak Ridge National Laboratory, TN (USA)); Ohr, S.M. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 62-63 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Dislocation emission from a crack tip along an inclined direction from the crack plane results in blunting of the crack tip. A dislocation free zone (DFZ) is formed. Additional dislocations are emitted from the blunt crack tip. The solution for the problem of dislocation pileup at a blunt crack tip with a DFZ has been obtained by applying the extended Wiener-Hopf technique to the pileup integral equation. A DFZ theory of fracture was developed earlier for the dislocation generation versus brittle fracture at the crack tip along the plane of the crack. This solution has been used to derive the critical K values for the inclined dislocation emission versus brittle extension at the blunt crack tip.

7984 Dislocation behavior in spinodally-modulated Cu-10Ni-6Sn alloy. Shekhar, S. (Michigan State Univ., East Lansing (USA)); Lee, T.C.; Subramanian, K.N. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 63 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Character of dislocations during their motion in spinodally-modulated Cu-10Ni-6Sn alloy aged for various lengths of time at 350 C were analyzed by combining video recording of dynamic events during straining and by using still photography for Burgers vector analysis, while the specimen was still under load. The results obtained are compared with those obtained by conventional TEM studies on deformed bulk specimens of the same alloy.

7985 Relationship between crack growth and crack initiation toughness. Ritchie, R.O. (Univ. of California, Berkeley (USA)); Thompson, A.W. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 63 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Relationships between crack initiation and crack growth toughness are examined through considerations of the crack tip fields and microscopic (local) and macroscopic (continuum) fracture criteria for the onset and continued quasi-static extension of cracks in ductile materials. Specifically, the distinction between the deformation fields directly ahead of stationary and non-stationary cracks is used to indicate why microstructure may have a more significant role in influencing the toughness of slowly growing cracks (e.g., the tearing modulus) as opposed to initiating cracks (e.g., K_{Ic}, J_{Ic}).

7986 Influence of inclusion spacing and void growth on the toughness of ultra high strength steels. Garrison, W.M. Jr. (Sandia National Laboratories, Livermore, CA (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 63 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The Rice and Johnson model for ductile fracture predicts that, for a fixed inclusion volume fraction and constant yield strength, the fracture toughness will be proportional to the square root of the inclusion spacing X_O. However, there are mechanisms which might result in the linking of voids and their joining to the crack tip before they attain the size permitted by the Rice and Johnson model. As a result, the fracture toughness should be dependent on both X_O and the extent of void growth. McMeeking's calculations of void growth based on the Rice and Tracey model suggest that the K_{Ic} of ultra high strength steels will scale as $X_O\ \sigma_y(R_V/R_I)^{\frac{1}{2}}$ where σy is the yield strength and (R_V/R_I) is the void radius divided by inclusion radius. This proposed scaling is consistent with the behavior exhibited by a series of ultra high strength steels.

7987 Microstructure and the toughness of the secondary hardening steel AF 1410. Garrison, W.M. Jr. (Sandia National Laboratories, Livermore, CA (USA)); Moody, N. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 64 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The secondary hardening steel, AF 1410, can be heat treated to achieve structures possessing both high yield strength and exceptionally high fracture toughness. The room temperature impact and fracture toughness of AF 1410 were measured as a function of aging temperature. The results are analyzed in terms of inclusion spacing and the degree to which microstructural changes on aging alter the extent of growth of voids initiated at inclusions.

7988 Mixed mode crack propagation in molybdenum. Ohr, S.M. (Oak Ridge National Lab., TN (USA)); Horton, J.A.; Chang, S.J.; Thomson, R. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 64 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Electron microscope studies of crack propagation in molybdenum have shown that cracks often propagate in a zig-zag manner preceded by dislocation emission on alternating slip planes. In order to have zig-zag crack propagation, two modes of fracture (modes I and II) must be in operation simultaneously. The authors have considered a mechanism of brittle fracture which is accompanied by crack tip deformation under mixed mode loading conditions. It is found that the dislocations emitted under pure mode II loading will shield mode II stress intensity factor, K_{II}, but mode I stress intensity factor, K_I, may not be affected. As the applied load is increased, it is therefore possible to have crack tip deformation in mode II while K_I continues to increase and reach K_{IC} to initiate brittle fracture.

7989 Chemical reactivity and covalent-metallic bonding of Si_n^+ (n≈11–25) clusters. Chelikowsky, J.R. (Department of Chemical Engineering and Materials Science, Minnesota Supercomputer Institute, University of Minnesota, Minneapolis, Minnesota 55455 (US)); Phillips, J.C. *Physical Review Letters (USA),* 63(15): 1653-1656 (9 Oct 1989).

Using our earlier thermodynamic force field we have calculated the equilibrium structures of medium-size Si_n clusters (n=1–25). We find the very surprising result that beginning at n=7, near n=13 and near n=19, these clusters follow a pentagonal growth pattern (icosahedra plus associated face capping). Our results are fully consistent with magic numbers recently found in the reaction rates for addition of first C_2H_4 molecules to Si_n^+ clusters.

7990 External-charge-induced surface reconstruction on Ag(110). Fu, C.L. (Metals and Ceramics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831-6114 (US)); Ho, K.M. *Physical Review Letters (USA),* 63(15): 1617-1620 (9 Oct 1989). DOE Contract AC05-84OR21400;W-7405-ENG-82.

The effect of external fields on the structural and electronic properties of Ag(110) is investigated using local-density-functional theory. We find that Ag(110) undergoes a (1×2) missing row reconstruction as an excess charge of ≅0.05 electron per surface atom is added onto the surface. Our result supports an electron-donation mechanism for the alkali-metals-induced reconstruction on the (110) surface of the 3*d* and 4*d* fcc metals. The surface interlayer spacings are found to be insensitive to the applied field in the absence of field-induced surface reconstruction.

7991 Lower and upper critical fields in the heavy electron superconductor UPt_3. Shivaram, B.S. (Department of Physics and Engineering Physics, University of Virginia, Charlottesville, Virginia 22901 (US)); Gannon, J.J. Jr.; Hinks, D.G. *Physical Review Letters (USA),* 63(16): 1723-1726 (16 Oct 1989).

We report the first comprehensive measurements of the lower critical field, H_{c_1}, for both orientations $H||a$ axis and $H||c$ axis, of the heavy electron superconductor UPt_3. An accurate signature for H_{c_1} is obtained in a *LC* oscillator whose resonance frequency changes on flux entry into the superconductor. The H_{c_1} values obtained with this technique indicate a "kink" for $H||a$ axis only. With this same technique we also measure the upper critical field, H_{c_2}. The results obtained are compared with predictions from recent theories of H_{c_1} and H_{c_2} in anisotropic superconductors.

7992 Different core-hole lifetime and screening in the surface of W(110). Riffe, D.M. (AT&T Bell Laboratories, Murray Hill, New Jersey 07974 (US)); Wertheim, G.K.; Citrin, P.H.;. *Physical Review Letters (USA),* 63(18): 1976-1979 (30 Oct 1989).

High-resolution 4*f* photoemission spectra from clean W(110) show that the natural lifetime width and the (electron-hole)-pair singularity index are both larger in the first atomic layer than in the bulk. Phonon broadening for the surface and bulk components are smaller than theoretical estimates, and little excess broadening is detected in the surface layer. These findings are very different from the conventional picture of surface-atom core-level line shapes and have implications extending to other systems.

7993 The propagation of a solid-state combustion wave in Ni-Al foils. Anselmi-Tamburini, U. (Division of Materials Science and Engineering, University of California, Davis, California 95616 (US)); Munir, Z.A.;. *Journal of Applied Physics (USA),* 66(10): 5039-5045 (15 Nov 1989).

The use of thin foils to investigate the propagation of a combustion wave has been demonstrated for the nickel-aluminum system. The initiation of a reaction wave in the foils was found to be triggered by the melting of nickel regardless of the composition of the foil ensemble. In contrast, the propagation rate decreased with increasing nickel content in the foil ensemble. Considerable interactions, observed in advance of the combustion front, are contrary to assumptions made in existing models on the dynamics of self-sustaining reactions. The nature and sequence of reactions between foils of Ni and Al and their relationship to the combustion front were determined.

7994 Amorphization reaction in thin films of elemental Cu and Y. Johnson, R.W. (W. M. Keck Laboratory of Engineering Materials, California Institute of Technology, Pasadena, California 91125 (US)); Ahn, C.C.; Ratner, E.R. *Physical Review [Section] B: Condensed Matter (USA),* 40(12): 8139-8145 (15 Oct 1989).

Compositionally modulated thin films of Cu and Y were prepared in an ultrahigh-vacuum dc ion-beam deposition chamber. The amorphization reaction was monitored by *in situ* x-ray-diffraction measurements. Growth of amorphous $Cu_{1-x}Y_x$ is observed at room temperature with the initial formation of a Cu-rich amorphous phase. Further annealing in the presence of unreacted Y leads to Y

enrichment of the amorphous phase. Growth of crystalline CuY is observed for T=469 K. Transmission-electron-microscopy measurements provide real-space imaging of the amorphous interlayer and growth morphology. Models are developed, incorporating metastable interfacial and bulk free-energy diagrams, for the early stage of the amorphization reaction.

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Refer also to citation(s) 6657, 6658, 6659, 6660, 6661, 6662, 6663, 6664, 6665, 6666, 6667, 6668, 6669, 6670, 6671, 6672, 6674, 6675, 6676, 6685, 6809, 6810, 7462, 7918, 7923, 7932, 8049, 8272, 8802

7995 (BNL–43006) **A systematic study of the effects of metal substitutions for Cu in $YBa_2(Cu_{1-x}M_x)_3O_{7-\rho}$, M = Fe, Co, Al, Ga, Cr, Ni, and Zn.** Xu, Youwen; Moodenbaugh, A.R.; Wang, Y.L.; Suenaga, M.; Sabatini, R.L. Brookhaven National Lab., Upton, NY (USA). [1989]. 9p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-891119–37: Materials Research Society fall meeting, Boston, MA (USA), 27 Nov - 2 dec 1989). Order Number DE90003957. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

A series of polycrystalline $YBa_2(Cu_{1-x}M_x)_3\ O_{7-\delta}$ (1:2:3) samples with a typical grain size >10μm was prepared using well controlled and reproducible procedures. This relatively large grain size allowed microprobe studies of individual grains to determine M content of the 1:2:3 phase. Solubility limits of substitutions for Cu in these samples are estimated. Superconducting transition temperatures and lattice parameters are presented. In the case of Ga, microprobe studies show no evidence for Ga content of 1:2:3 above x = 0.01. Preliminary studies show no evidence for solid solution above x = 0.01 when substituting Mn, Cr, Zr, and Ti for Cu in 1:2:3. 9 refs., 1 fig., 1 tab.

7996 (BNL–43068) **Atomic scale structure of twin boundary in Y-Ba-Cu-O superconductors.** Zhu, Yimei (Brookhaven National Lab., Upton, NY (USA)); Suenaga, M.; Xu, Youwen; Kawasaki, M. Brookhaven National Lab., Upton, NY (USA). [1989]. 7p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-891119–36: Materials Research Society fall meeting, Boston, MA (USA), 27 Nov - 2 dec 1989). Order Number DE90003955. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

High resolution electron microscopy of the twin boundary layers in Y $Ba_2(Cu_{1-x}M_x)_3O_{7-\delta}$ for x=0 and 0.02 and M=Zn, Fe and Al showed that the boundary widths are ~1 nm for the pure and the Zn substituted Y $Ba_2Cu_3O_7$, 2.5 ~ 3 nm for the Fe and Al substituted oxide. It was found that the lattice plane is shifted across the twin boundary by $(1/3 \sim 1/2)\cdot 2d_{(110)}$ along the boundary. The broadening of the layer for the cases of Fe and Al is also thought to be associated with a reduction of the twin boundary energy, which also leads to an increased twin density.

7997 (BNL–43137) **Effects of non-linearity in the variation of pinning potential with current-density on magnetic flux creep in high and low T_c superconductors.** Welch, D.O.; Suenaga, M.; Xu, Youwen; Ghosh, A.K. Brookhaven National Lab., Upton, NY (USA). [1989]. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-891137–1: 2. international symposium on superconductivity, Tsukuba (Japan), 14-17 Nov 1989). Order Number DE90003952. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

A theoretical analysis is presented of the effects on magnetic flux creep of non-linearity in the relation between the activation energy required for the depinning of magnetic flux and the current density. The non-linearity results in an apparent temperature dependence of the depinning energy as deduced by the conventional methods of analysis of flux-creep data. The discussion is illustrated with data for $YBa_2Cu_3O_7$ and Nb_3Sn. 5 refs., 6 figs.

7998 (BNL–43576) **The fabrication of $YBa_2Cu_3O_7$ thin films by thermal coevaporation in oxygen.** Wiesmann, H.; Chen, De Huai. Brookhaven National Lab., Upton, NY (USA). [1989]. 5p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-891119–35: Materials Research Society fall meeting, Boston, MA (USA), 27 Nov - 2 dec 1989). Order Number DE90003960. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Thin films of $YBa_2Cu_3O_7$ have been fabricated by the technique of thermal coevaporation in oxygen. Details of the deposition system design and process are presented. Preliminary results are presented for films grown on magnesium oxide substrates. The films are characterized by x-ray diffraction and the quality of their superconducting transition. 10 refs., 3 figs.

7999 (CONF-8908192–1) **Properties of high T_c superconducting oxides.** Veal, B.W.; Chan, S.-K. Argonne National Lab., IL (USA). Oct 1989. 16p. Sponsored by U.S. DOE Energy Research. DOE Contract W-31109-ENG-38. From 7. world round table conference on sintering; Herceg-Novi (Yugoslavia); 28 Aug - 1 sep 1989. Order Number DE90003792. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

In this paper we shall first briefly consider the history of oxide superconductor discoveries followed by a brief sketch of the current state of theory. We then consider crystallographic structures of the high-T_c oxide superconductors. We will then examine some phase fields (T_c versus composition) of the oxide superconductors. Since these phase fields show continuous variation between superconducting (metallic) and insulating behavior, they contain both these elements favorable to superconductivity and those detrimental. Particularly well studied are the remarkably variable physical properties of the 123 superconductor that are associated with varied oxygen stoichiometry and cation substitution. We present selected results to provide a brief overview of this problem. Then recent work on electronic properties, providing insight into the fundamental nature of electronic conduction will be examined. These consideration impact on the problem of sintering. Sample density, grain size, grain boundary impurities and texture all affect the physical properties. Of particular importance to superconducting properties is the control of oxygen stoichiometry and sample homogeneity associated with dispersal of dopant ions. 7 refs., 14 figs.

8000 (Juel-Spez–513) **Boron nitride coatings. Preparation, characteristics and applications.** Scientific series of the International Bureau, Kernforschungsanlage Juelich GmbH. Marinkovic, S.; Marinkovic, Z.; Koetter, H.; Meixner, C. Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Internationales Buero. 1989. 81p. Order Number DE90732583. Available from NTIS (US Sales Only), PC A05/MF A01.

This study aims at presenting an up-to-date review of the recent literature covering BN preparation by both CVD and PVD methods, as well as their characteristics and existing and possible applications. (orig./MM).

8001 (KFK–4583) **Material interactions between system components and glass product melts in a ceramic melter.** Knitter, R. Kernforschungszentrum Karlsruhe G.m.b.H. (Germany, F.R.). Inst. fuer Nukleare Entsorgungstechnik; Kernforschungszentrum Karlsruhe G.m.b.H. (Germany, F.R.). Projekt Wiederaufarbeitung und Abfallbehandlung; Muenster Univ. (Germany, F.R.). Mathematisch-Naturwissenschaftliche Fakultaet. Jul 1989. 154p. (In German). Order Number DE90732508. Available from NTIS (US Sales Only), PC A08/MF A01.

The interactions of the ceramic and metallic components of a ceramic melter for the vitrification of High Active Waste were investigated with simulated glass product melts in static crucible tests at 1000°C and 1150°C. Corrosion of the fusion-cast Al_2O_3-ZrO_2-SiO_2- and Al_2O_3-ZrO_2-SiO_2-Cr_2O_3-refractories (ER 1711 and ER 2161) is characterized by homogeneous chemical dissolution and diffusion through the glass matrix of the refractory. The resulting boundary compositions lead to characteristic modification and formation of phases, not only inside the refractory but also in the glass melt. The attack of the electrode material, a Ni-Cr-Fe-alloy Inconel 690, by the glass melt takes place via grain boundaries and leads to the oxidation of Cr and growth of Cr_2O_3-crystals at the boundary layer. Noble metals, added to the glass melt can form solid solutions with the alloy with varying compositions. (orig.).

8002 (LBL–25457) **Cyclic fatigue-crack propagation in ceramics: Behavior in overaged and partially-stabilized MgO-zirconia.** Dauskardt, R.H. (Lawrence Berkeley Lab., CA (USA)); Marshall, D.B.; Ritchie, R.O. Lawrence Berkeley Lab., CA (USA).

Jun 1988. 16p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00098. (CONF-880529–9: MRS international meeting on advanced materials, Tokyo (Japan), 30 May - 3 jun 1988). Order Number DE90004247. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The growth of fatigue cracks under (tension-tension) cyclic loading is unequivocally demonstrated for ceramic materials, based on experiments using compact-tension specimens of a MgO partially-stabilized zirconia (PSZ), heat treated to vary the fracture toughness K_c from ~3 $MPa\sqrt{m}$ (overaged condition) to 16 $MPa\sqrt{m}$ (peak-toughness condition) and tested in inert and moist environments. Analogous to behavior in metals, cyclic fatigue-crack growth rates (over the range 10^{-11} to 10^{-5} m/cycle) are found to be a function of the stress-intensity range, environment, fracture toughness and load ratio, and to show evidence of crack closure. Similarly under variable-amplitude cyclic loading conditions, crack-growth rates show transient accelerations following low-high block overloads and transient retardations following high-low block overloads or single tensile overloads, again analogous to behavior commonly observed in ductile meals. Cyclic crack-growth rates are observed at stress intensities as low as 50% of K_c, and are typically some 7 orders of magnitude faster than corresponding stress-corrosion crack-growth rates under sustained-loading conditions. 23 refs., 6 figs.

8003 (ORNL/FMP–87/4, pp. 3-27) **Processing and properties of SiC/Nicalon composites.** Lowden, R.A. (Oak Ridge National Lab., TN (USA)); Caputo, A.J.; Stinton, D.P.; Besmann, T.M.; Morris, M.D. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

A statistically designed experiment was performed to evaluate the effects of process variables on fiber-reinforced SiC composites fabricated by chemical vapor infiltration. Response surface methodology was applied to study the influence of temperature, pressure, reactant supply rate, and gas ratios on the deposition process and the properties of the produced material. Deposition temperature and total gas flow rates had inverse effects on density and strength, while the effect of pressure was statistically insignificant. Low H_2:CH_3SiCl_3 ratios evoked a positive response in all dependent variables.

8004 (ORNL/FMP–87/4, pp. 28-55) **Development of advanced fiber reinforced ceramics.** Starr, T.L. (Georgia Tech Research Institute, Atlanta (USA)); Harris, J.N. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Silicon nitride composites with random, short fiber reinforcement have been fabricated using reaction sintering techniques. Large diameter fiber yields high density composites but degradation of fiber during nitriding limits property gains. Small diameter whiskers with better high temperature stability yield low density composites using currently available silicon powders. Future work will focus on coatings to stabilize fibers, new fibers with better high temperature stability and finer silicon powers for whisker composites.

8005 (ORNL/FMP–87/4, pp. 56-73) **Ceramic filter failure analysis.** Chang, R. (Acurex Corp., Mountain View, CA (USA)); Sawyer, J.; Okoh, C. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Ceramic filters offer a promising approach for particulate control from high temperature gas streams. The major concern is the long-term durability of these filters in the hostile environment of the hot corrosive gas stream. The objective of the program is to determine the causes of ceramic filter failure during use and to propose development work needed to improve the reliability of these filters. A literature search was conducted to determine the major types of ceramic filters. Manufacturers and users of the filters were contacted to determine their application experience with various filter types and to obtain samples for further analysis. Failure analysis was conducted on different samples using a combination of surface and structural analysis techniques including SEM, EDX, EPMA, AES and X-ray diffraction. Stress analysis was performed to relate filter mechanical properties with areas of stress concentration during use. This paper summarizes the effort to date on failure analysis.

8006 (ORNL/FMP–87/4, pp. 74-88) **Improved ceramic composites through fiber-matrix interaction.** Bates, J.L. (Pacific Northwest Lab., Richland, WA (USA)); Griffin, C.W.; Weber, W.J.; Courtright, E.L. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Preliminary analyses of matrix/fiber interactions between Si_3N_4 matrix with 5 wt.% MgO added as a sintering aid, and Nicalon™[(b)] silicon carbide fibers have been performed. Specimens with 0, 10, and 30 vol.% fibers were prepared by hot pressing at 1750°C in one atmosphere of nitrogen. Specimen characterization revealed that a significant amount of magnesium diffuses into the silicon carbide fibers during fabrication. Free carbon on the surface of the Nicalon™ appears to play an important role in debonding. No evidence of Si enrichment or SiO_2 formation have been found at the interfaces.

8007 (ORNL/FMP–87/4, pp. 89-104) **Effect of flaws on the fracture behavior of structural ceramics.** Singh, J.P. (Argonne National Lab., IL (USA)); Roberts, R.A.; Vaitekunas, J.J.; Ellingson, W.A. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Fracture studies and nondestructive evaluation (NDE) were performed to detect and assess the effect of flaws on the fracture behavior of hot-pressed Si_3N_4 with Fe inclusions. The NDE methods used were through-transmission and backscatter ultrasound and low-kV contact radiography. The addition of 5 and 0.5 wt % Fe inclusions of 88 to 250 μm sized reduced the strength of Si_3N_4 specimens by approximately 40 and 15%, respectively. Fractography indicated that failure occurred primarily from internal flaws which included Fe- and Si-rich inclusions and/or regions of Si_3N_4 matrix that were degraded as a result of reaction between Si_3N_4 and molten Fe. For Fe inclusion-induced internal flaws, the critical flaw sizes calculated by fracture mechanics were always larger than the fractographically measured flaw sizes. This observation suggested a local degradation in fracture toughness of Si_3N_4 matrix. A ratio, K, of $\approx$ 3.5 to 4.2 appeared to exist between the calculated and measured values of the critical internal flaw sizes. The ratio K will have important implications for strength prediction based on observed flaw size. A comparison of the fractography and NDE results for the location of critical flaws indicated that the backscatter ultrasound method may be more suitable than through-transmission ultrasound or low-kV contact radiography for the detection of near-surface flaws.

8008 (ORNL/FMP–87/4, pp. 147-155) **Materials development for solid oxide oxygen production unit.** Easler, T.E. (Argonne National Lab., IL (USA)); Poeppel, R.B. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

The implementation of a solid oxide oxygen pump in coal gasification systems is believed to have the potential for significantly reducing the cost of oxygen generation for the gasification process. The solid oxide oxygen pump concept is based on the oxygen-ion conducting behavior of zirconia ceramics. The approach being taken to fabricate the oxygen pump involves fabrication of thin multilayer structures of ceramic electrode and electrolyte materials by the tape casting process. It is desired to make the laminated structures as thin as possible to minimize internal power losses which are the result of the high resistances of the individual ceramic oxide layers. Both the air and oxygen electrodes are made of strontium-doped lanthanum manganite. The particular ceramic electrolyte under development in this project is zirconia doped with 8 mol % Y_2O_3. This study is particularly concerned with determining the

types of failure modes that may be associated with the very thin ceramic layers. The fabrication of the layers, and the initial failure mode identification tests, are described in this paper.

8009 (ORNL/FMP–87/4, pp. 156-167) **Fiber-reinforced composite hot-gas filters.** Stinton, D.P. (Oak Ridge National Lab., TN (USA)); Lowden, R.A.; Chang, R. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

A chemical vapor deposition process was developed for the fabrication of high-temperature particulate filters. Fibrous materials such as Nicalon (SiC) felt and aluminosilicate papers were used as the filter material. Preliminary evaluation of filter specimens fabricated from Nicalon revealed extremely encouraging results. Cleanable filters with collection efficiencies of >99.% were recorded for both PFBC fly ash and gasifier char.

8010 (ORNL/FMP–87/4, pp. 168-184) **Nondestructive evaluation of advanced ceramic composite materials.** Walter, J.B. (Idaho National Engineering Lab., Idaho Falls (USA)); Lott, L.A. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Ceramic composites are an important new type of material being developed for applications requiring high strength at high temperatures. Considered here are composites of a SiC matrix reinforced with SiC fabric which is formed by chemical vapor infiltration of the fabric. An important aspect of this process is the formation of extensive porosity which limits the strength of the material. Effective methods of nondestructively detecting and characterizing porosity in the material are needed. This is a challenging task for ultrasonic techniques because of the high levels of porosity (typically 10-50%) found in the material and because of the intrinsic heterogeneity and anisotropy of the material, all of which strongly affect ultrasonic wave propagation. Through-transmission techniques for measuring ultrasonic properties are described, including the use of time delay spectrometry and laser generation of ultrasound. Acoustic properties and area scans are presented for samples containing a range of porosity. It is concluded that the techniques are adequate to form a technical basis for developing effective ultrasonic NDE methods.

8011 (ORNL/FMP–87/4, pp. 185-204) **Advanced materials for solid oxide fuel cells.** Griffin, C.W. (Pacific Northwest Lab., Richland, WA (USA)); Bates, J.L. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Materials based on the In_2O_3-$PrO_{1.83}$-ZrO_2 system were examined as potential electrodes and current interconnects for solid oxide fuel cells (SOFC). The electrical transport, thermal, and electrochemical properties are described in relationship to structure, phase equilibria, and composition. The electrical conductivity was dependent on structure and composition, and can exceed the conductivity of the stat-of-the-art electrode/interconnect materials. The instability of the In_2O_3 in reducing environments may eliminate this system as SOFC anodes or interconnects. This system may be used as cathodes if indium does not diffuse into the electrolyte and degrade fuel cell performance.

8012 (ORNL/FMP–87/4, pp. 205-225) **Whisker reinforced structural ceramics (progress in the VLS growth and use of long silicon carbide whiskers).** Gac, F.D. (Los Alamos National Lab., NM (USA)); Shalek, P.D.; Parkinson, W.J.; Edwards, C.; Price, J.B. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

A Vapor-Liquid-Solid (VLS) whisker growth process, optimized for the production of short ($\approx$ 10 mm lengths) SiC whiskers, was modified to produce $\geq$ 25 mm long whiskers. In conjunction with this modification, a plan was developed for incorporating Al system to enhance the whisker growth process. An oriented whisker ribbon was produced from the long whiskers, as a step toward the development of a stable whisker yarn.

8013 (ORNL/FMP–87/4, pp. 226-234) **Modeling of fibrous preforms for CVD infiltration.** Starr, T.L. (Georgia Tech Research Institute, Atlanta (USA)). Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Chemical vapor infiltration using combined pressure and temperature gradients results in dramatically shorter fabrication times for ceramic composites. A microstructural model for the fibrous preform and the intermediate, partially densified composite is used to predict gas flow and temperature throughout the body. Combined with kinetics data, the model allows calculation of the density distribution during the infiltration process. Predicting the effect of modifications to the process and of changes in preform structure, the model aids optimization of processing conditions, structure and properties.

8014 (ORNL/FMP–87/4, pp. 235-269) **Joining of silicon carbide-reinforced ceramics.** Coon, D.N. (Idaho National Engineering Lab., Idaho Falls (USA)); Neilson, R.M. Jr. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Advances in polymer and metal matrix composites have elevated them to the status of practical engineering materials, and prompted intensive research to develop advanced ceramic fiber/ceramic matrix composites for high temperature applications. This research is to identify and develop techniques for joining silicon carbide fiber-reinforced ceramic composites of tubular geometries, primarily through the use of glass joining materials. Tasks include; identifying, preparing, and characterizing glass compositions suitable for joining ceramic/ceramic composites; developing a joining methodology and evaluating the effects of process parameters on joint characteristics; fabricating and characterizing joints; determining physical/mechanical properties and failure behavior of joints under ambient conditions, elevated temperatures, and simulated service environments. The major effort has been to characterize glass compositions for use as joining materials. Four requirements for the glass brazing material were identified; (1) The glass joining material should melt and flow at temperatures below those reported to degrade the properties of the composite material (approximately 1200°C). (2) The glass joining material should not exhibit excessive chemical reactivity with SiC. (3) Ideally, the devitrified glass joint should exhibit good mechanical properties to 1000°C. (4) The glass composition should devitrify to crystalline phases which exhibit low thermal expansion and good chemical resistivity to promote thermal and chemical stability of the resulting joint. Study results are discussed against these requirements.

8015 (ORNL/FMP–87/4, pp. 270-292) **Development of nondestructive evaluation methods for structural ceramics.** Ellingson, W.A. (Argonne National Lab., IL (USA)); Roberts, R.A.; Vannier, M.W.; Ackerman, J.L.; Sawicka, B.D.; Gronemeyer, S.; Kriz, R.J. Oak Ridge National Lab., TN (USA). Aug 1987. (CONF-8705103–: Fossil energy materials program conference, Oak Ridge, TN (USA), 19-21 May 1987). In *Fossil Energy Materials Program conference proceedings.* Order Number DE88002250. Available from NTIS, PC A99/MF A01.

Advanced nondestructive evaluation methods are being developed to characterize ceramic materials and allow improvement of process technology. If one can spatially determine porosity, map organic binder/plasticizer distributions, measure average through-volume and in-plane density, as well as detect inclusions, process and machining operations may be modified to enhance the reliability of ceramics. Two modes of X-ray tomographic imaging – advanced film (analog) tomography and computed tomography – are being developed to provide flaw detection and density profile mapping capability. Nuclear magnetic resonance imaging is being developed to determine porosity and map the distribution of organic binder/

plasticizer. Ultrasonic backscatter and through-transmission are being developed to measure average through-thickness densities and detect surface inclusions.

8016 (ORNL/TM–10373) **Extrusion of alumina-silicon carbide whisker composites.** Janney, M.A.; Bomar, E.S.; Vance, M.C. Oak Ridge National Lab., TN (USA). Oct 1989. 30p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC05-84OR21400. Order Number DE90004379. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A method was developed to extrude tubes of alumina-silicon carbide whisker composites and the mechanical properties of extruded material were determined. Extruded parts had good strength (~300 MPa) and excellent thermal shock properties ($\Delta T_{crit} > 900°C$). Extruded alumina-silicon carbide whisker composites represent a prime candidate for use as heat exchanger tubes. 7 refs., 10 figs., 8 tabs.

8017 (SAND–89-1791C) **Preparation and properties of icosahedral borides.** Aselage, T.L.; Tallant, D.R.; Gieske, J.H.; Van Deusen, S.B.; Tissot, R.G. Sandia National Labs., Albuquerque, NM (USA). 1989. 15p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-8909274–1: NATO ARW - the physics and chemistry of carbides, nitrides, and borides, Manchester (UK), 18-22 Sep 1989). Order Number DE90003574. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The electronic and thermal transport properties of refractory icosahedral boron-rich solids suggest the utilization of these unique solids as high-temperature semiconductors. Such applications will require high-quality, well-characterized materials. A variety of techniques have been used to prepare powders, ceramics, and single crystals of boron carbides and the icosahedral boron pnictides. X-ray diffraction, Raman spectroscopy, and ultrasound measurements have been used to probe boron carbide sample quality. Each of these measurements supports the structural model of boron carbides developed from analysis of transport data. Initial electrical conductivity ($E_a \approx 0.17$ eV) is consistent with a bipolaronic hopping mechanism. 43 refs., 6 figs., 1 tab.

8018 **MBE growth of compositionally modulated ceramics.** McKee, R.A. (Oak Ridge National Lab., TN (USA)); List, F.A.; Walker, F.J. pp. 365 of Multilayers: Synthesis, properties and nonelectric applications. Aung, W. Materials Research Society, Pittsburgh, PA (1988). DOE Contract AC05-84OR21400. (CONF-8711143–: Symposium on multilayers: synthesis, properties and nonelectronic applications, Boston, MA (USA), 30 Nov - 4 dec 1987).

An ultra high vacuum system fitted with thermal effusion cells that heat 20cc of material to temperatures as high as 2000°C is being used to synthesize thin film and multilayer ceramics from their constituent elements. A molecular source for oxygen used in conjunction with these effusion cells allows oxides of Al, Ti, Cu, and Y to be grown with compositional modulation controlling growth rate and stoichiometry.

8019 **Deflection of light by using tungsten bronze crystals.** Jelsma, L.F. (Lawrence Livermore National Lab., CA (USA)); McWright, G.M.; Schumacher, F.A.; Neurogaonkar, R.R. pp. 262 of Optoelectronic materials, devices, packaging, and interconnects II. McWright, G.M.; Wojtunik, H.J SPIE Society of Photo-Optical Instrumentation Engineers, Bellingham, WA (1988). DOE Contract W-7405-ENG-48. (CONF-8809111–: Optoelectronic materials, devices, packaging, and interconnects II, Boston, MA (USA), 6-10 Sep 1988).

This paper reports preliminary results on an electrooptical light deflector for streak camera applications that uses tungsten bronze SBN:60% crystals. The authors find the performance of these ferroelectric crystals to be an order of magnitude better than the best $LiNbO_3$ crystals currently available. They discuss the theory and performance of this crystal as well as other bronze crystals for application to the streak camera.

8020 **Swelling and outgassing of tritiated lithium hydride compacts.** Souers, P.C. (Lawrence Livermore National Lab., CA (USA)); Folkers, C.L.; McCreary, T.; Snider, G.D.; Vanderhoofven, F.; Tsugawa, R.T.; Anderson, J.L.; Lewis, W.B.; Nasise, J.E.; Pretzel, F.E. *Journal of Nuclear Materials, on Metallurgy, Ceramics and Solid State Physics in the Nuclear Energy Industry (Netherlands),* 168(1/2): 1-11 (Oct-Nov 1989). DOE Contract W-7405-ENG-48;W-7405-ENG-36;AC04-76DP00053.

Additional lithium deuteride-tritide [Li(D, T)] compact bulk swelling and outgassing data from 77 to 273 K and 373 to 723 K is presented. A swelling maximum is seen at 425 K and a minimum at 575 K. The largest swelling is seen at 723 K. Variable-temperature experiments show that the mechanism turns on progressively as the temperature is raised to the maximum. The percent of ^3He outgassed is presented and shown not to affect the bulk swelling. The forces involved in swelling are illustrated by the 270 MPa needed to restrain it at 323 K. Hardness data is also listed. The swelling at 323 and 348 K is analyzed and the slow linear region II growth is shown not to correspond to the ^3He production rate. The behavior more closely fits radiation-induced creep. (orig.).

8021 **Crystal growth of $YBa_2Cu_3O_7$ superconductors.** McGee, T.F. (North American Philips Corp., Briarcliff Manor, NY (USA)); Loiacono, G.M. *Materials Research Bulletin (USA),* 24(1): 95-102 (Jan 1989).

The authors report on attempts to grow single crystals of $Y^*Ba_2Cu_3O_7$ by precipitation from inorganic oxide fluxes at atmospheric pressure and by melting off-stoichiometric compositions at oxygen pressures ranging from 1 to 5 atmospheres. The choice of crystal growth method is limited because of the peritectic decomposition of this material. The $YBa_2Cu_3O_7$ compound was not formed in any of the oxide flux systems investigated. It is clear that the instability of the compound is a major problem in crystal growth. Similar to the work of others, small thin plates (mm size range) were grown by melting off-stoichiometric compositions in flowing O_2. Samples containing these plates embedded in the solidified melt show an onset of diamagnetism at $^{-}90^0K$. EDAX analysis showed the ratio of Y/Ba/Cu to be 1/2/3 which corresponds to the correct stoichiometry for the superconducting compound. X-ray analysis on one of the plates showed it consisted of one large single crystal grain and a few small grains of different orientations.

8022 **Heat and fluid flow during the formation of metallic glasses by splat cooling.** Brower, W.E. Jr. (Southern Illinois Univ., Carbondale (USA)); Karoglanian, S.; Megli, S.C. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 23 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

A model is presented for heat and fluid flow during hammer and anvil splat cooling. Predictions are made for the effects of superheat and hammer speed on splat thickness, cooling rate, and subsequent glass formation. The regime of Newtonian heat flow is extended well beyond the previously accepted limiting value of Nusselt number. Measurements of the structure, stability, and thickness of $Fe_{80}B_{20}$ and $Pd_{80}Si_{20}$ hammer and anvil splats qualitatively confirm the model prediction. Variations of superheat in shock tube splats produced similar trends to those observed in the hammer and anvil device. In an attempt to vary the equivalent of hammer speed in a shock tube device, an orifice producing a supersonic shock wave was utilized. Significant splat flake thickness reductions resulted as compared to subsonic orifices.

8023 **Effects of thermal annealing on the chemical and physical properties of shear bands.** Vianco, P.T. (Univ. of Rochester, NY (USA)); Li, J.C.M. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 35 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Inhomogeneous flow in metallic glasses is revealed in the form of shear bands. A study of the effect of annealing on the chemical etchability of shear bands in Metglas 2826 ($Fe_{40}Ni_{40}P_{14}B_6$) and $BNi_2(Ni_{69.2}B_{13.7}Si_{7.9}Cr_{6.6}Fe_{2.6})$ brazing alloy was performed. It is found that the etchability of shear bands could be eliminated after a certain time period characteristic of the isothermal annealing temperature. This property was used to determine the apparent activation energy of the loss of chemical etchability of the bands. In the BNi_2 alloy, the etching properties following annealing are compared to the effect of annealing on the reverse shear behavior of the shear bands.

8024 **Annealing of Metglas 2826B under applied tensile stresses.** Vianco, P.T. (Univ. of Rochester, NY (USA)); Li, J.C.M. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 35

(Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Because of the non-equilibrium nature of the structure of as-quenched metallic glasses, thermal annealing of these materials causes the structure to relax into a more stable configuration. In the temperature range of 177 C to 245 C, isothermal annealing of Metglas 2826B for time intervals of 530, 1060, and 1590 minutes show an increase in the microhardness of the material. However, it is demonstrated that under the same annealing schedule but with applied tensile loads from 20 to 400 MPa, a much smaller increase in microhardness is noted. These experimental results are evaluated in terms of the effect of tensile loading on the structural relaxation of this alloy. In addition, the role of structural relaxation in the primary creep of this material is discussed in the light of the above results.

8025 **Microstructure and processing of a ternary iron-rare earth-boron hard magnetic compound.** Das, B.N. (Naval Research Laboratory, Washington, DC (USA)); Koon, N.C.; D'Antonio, P. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 35 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Crystallized melt spun amorphous ribbons of iron-rare earth-boron, $Fe_{78.3}R_{15.0}B_{6.7}$ where R=Nd, Pr, Tb and La, show both high coercivity and large saturation magnetization. The superior magnetic properties in these crystallized ribbons are due to the presence of a ternary hard magnetic compound and a favorable microstructure. This compound exists near the iron rich corner of the ternary system. The X-ray diffraction results and intensity calculation support the presence of one of the proposed compounds, i.e., $Fe_{14}R_2B_1$. Based on the chemical formula (composition) several single crystal growth experiments were performed. The microstructures of the grown rods provided useful information about the phase equibria near the iron rich corner of the ternary system and thereby guided our crystal growth experiments.

8026 **Elastic phase transformation of $LaNb_{1-x}V_xO_4$ compounds.** Chan, S.K. (Argonne National Laboratory, IL (USA)); Aldred, A.T.; Grimsditch, M.H.; Nevitt, M.V. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 37 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

$LaNbO_4$ undergoes an elastic phase transformation in which the crystal structure changes from the tetragonal C^6_{4h} to the monoclinic C^6_{2h} symmetry by a homogeneous lattice deformation. The transformation is of the continuous type, with vanishing second order elastic constants at the transformation temperature which corresponds to the sound velocity going to zero in some direction. Higher order elastic constants provide the coupling of the homogeneous lattice deformation to the thermal expansion of the cell dimensions. X-ray diffraction experiments have been carried out to determine the structural changes and the effect of V substitution on phase stability. Concurrently, Raman scattering experiments have been performed to obtain the force constants up to two shells of neighbors. The characteristics of the transformation and the cause of the lattice instability are elucidated in terms of these data.

8027 **Superconducting behavior and chemistry of $Pb_{0.3}Bi_{1.8-x}Sb_xSr_{1.9}Ca_2Cu_3O_y$.** Dabrowski, B. (Argonne National Lab., IL (USA)); Richards, D.R.; Hinks, D.G.; Hannon, R.H.; Peng, W.; Lee, H.; Genis, A.P.; Melim, V.J.; Kimball, C.W. *Physica C: Superconductivity (Netherlands),* 160(3/4): 281-286 (15 Sep 1989). DOE Contract W-31-109-ENG-38.

We have studied the effect of Sb substitution in single phase Pb-doped Bi2223 superconducting compounds. We do not find evidence for the existence of any superconducting transition above 110 K. The Sb solubility in the 2223 phase is below our detection limit and cannot be increased by varying the firing conditions. Using the Moessbauer effect measurements we find that Sb is always near the +5 oxidation state for samples prepared under oxidizing and mildly oxidizing conditions. (orig.).

8028 **Aluminum doped zinc oxide thin films deposited by ion beam sputtering.** Ruth, M. (Solar Energy Research Inst., Golden, CO (USA)); Tuttle, J.; Goral, J.; Noufi, R. *Journal of Crystal Growth (Netherlands),* 96(2): 363-368 (Jun 1989). DOE Contract AC02-83CH10093.

Thin films of transparent conducting aluminum-doped ZnO (ZnO:Al) have been deposited by ion beam sputtering. The dependence of electrical and optical characteristics upon aluminum content in the films and upon post deposition annealing has been examined. Films have been produced with resistivities of $1x10^{-3}$ Ω cm and absorption coefficients of 3100 cm^{-1} in the visible region. By annealing at temperatures of 350-500^{0}C, the achieved resistivities and absorption coefficients are $(5\text{-}6x)10^{-4}$ Ω cm and 1500-1000 cm^{-1}, respectively. (orig.).

8029 **Growth of $Sr_xBa_{1-x}Nb_2O_6$ single crystal fibers.** Yamamoto, J.K. (Pennsylvania State Univ., University Park, PA (USA). Materials Research Lab.); Bhalla, A.S. *Materials Research Bulletin (USA),* 24(6): 761-765 (Jun 1989).

The growth of tungsten bronze $Sr_xBa_{1-x}Nb_2O_6$ (x=0.5, 0.61) single crystals have been achieved using a laser heated pedestal growth (LPHG) technique. The crystals were grown from ceramic rods and were approximately 500 μm in diameter. The growth direction was parallel to the c-axis. Preliminary electrical measurements indicate that the crystals are ferroelectric and optical observations show that these crystals appear to be striation free.

8030 **Electrostrictive properties of the lead zirconate titanate solid-solution system.** Haun, M.J. (Pennsylvania State Univ., University Park, PA (USA). Materials Research Lab.); Zhuang, Z.Q.; Furman, E.; Jang, S.J.; Cross, L.E. *Journal of the American Ceramic Society (USA),* 72(7): 1140-1144 (Jul 1989).

Values of the electrostrictive constants for the lead zirconate titanate (PZT) solid-solution system were required to complete the development of a thermodynamic phenomenological theory of PZT. The electrostrictive constant was measured as a function of composition on polycrystalline ceramic PZT samples. These data are used with additional single-crystal and ceramic data from the literature to approximate the compositional dependence of the electrostrictive constants of the PZT system. Series and parallel equations, analogous to the Voigt and Reuss models for the elastic constants, are used to relate the ceramic and single-crystal data, and to predict the upper and lower bounds of the ceramic electrostrictive constants from the single-crystal constants.

8031 **Mechanisms of improvement of fracture strength in laser-surface-modified ceramics.** Jagannadham, K. (North Carolina State Univ., Raleigh, NC (USA). Dept. of Materials Science and Engineering); Narayan, J. *Journal of the American Ceramic Society (USA),* 72(7): 1185-1191 (Jul 1989).

Three mechanisms of improvement in fracture strength of laser-surface-modified ceramic materials are proposed to explain the experimental observations of more than 50% increase in fracture strength. First, the improvement in fracture strength by about 50% is considered to arise from either a complete or partial closure of crack surfaces at the interface of the laser-modified overlayer. The second mechanism of improvement in fracture strength is derived from the physical displacement of the crack tip away from the free surface when a laser-modified layer is introduced. Thus, the critical crack size, defined as a crack that propagates with decreasing energy, is increased almost 100%. The third mechanism is based upon the compressive stresses introduced in the laser-modified region. The fast cooling rates attained after laser irradiation are responsible for development of regions of compressive internal stresses. These sources of improvement in fracture strength are analyzed and the results of the calculations compared with experimental results.

8032 **Spatially resolved Raman spectroscopy study of transformed zones in magnesia-partially-stabilized zirconia.** Davskardt, R.H. (Lawrence Berkeley Lab., CA (USA). Center for Advanced Materials); Veirs, D.K.; Ritchie, R.O. *Journal of the American Ceramic Society (USA),* 72(7): 1124-1129 (Jul 1989). DOE Contract AC03-76SF00098.

Raman vibrational spectroscopy provides an effective phase characterization technique in materials systems containing particle dispersions of the tetragonal and monoclinic polymorphs of zirconia, each of which yields a unique Raman spectrum. An investigation is reported to assess a novel, spatially resolved Raman spectroscopy system in the study of transformed zones surrounding cracks in partially stabilized $MgO\text{-}ZrO_2$ (PSZ). The experimental arrangement uses an imaging (two-dimensional) photomultiplier tube to produce a

one-dimensional Raman profile of phase compositions along a slit-like laser beam without translation of either the sample or the laser beam and without scanning the spectrometer. Results from phase characterization studies of the size, frontal morphology, and extent of transformation of transformation zones surrounding cracks produced under monotonic and cyclic loading conditions are presented.

8033 Particle interactions in zirconia-toughened alumina. Wilfinger, K.R. (Lawrence Livermore National Lab., CA (USA)); Cannon, W.R. *Journal of the American Ceramic Society (USA),* 72(7): 1256-1258 (Jul 1989).

In order to determine the effect of the coarse tail of the ZrO_2 size distribution of the monoclinic ZrO_2 content of zirconia-toughened alumina, quantitative hot-stage X-ray measurements were made on AL_2O_3-10% ZRO_2 (submicrometer with a coarse tail >1 μm), Al_2O_3-10% ZrO_2 with the coarse tail of the ZrO_2 carefully removed by centrifugation, and Al_2O_3-10% ZrO_2 in which 10% of ZrO_2(1) and 90% of ZrO_2(2) were used. The monoclinic content of the third measurement was compared with the weighted average of the first two. A disproportionate amount of monoclinic ZrO_2 was found in the third and its was concluded that transformation of the coarse particles promotes transformation in finer particles. Microstructural examination supports this conclusion. Results are interpreted as being dus both to autocatalytic transformation and to constraint relief from microcracking.

8034 Lorentz-force independence of resistance tails for high-temperature superconductors in magnetic fields near T_c. Woo, K.C. (Materials Science Division, Argonne National Laboratory, Argonne, Illinois, 60439 (US)); Gray, K.E.; Kampwirth, R.T.; Kang, J.H.; Stein, S.J.; East, R.; McKay, D.M.;. *Physical Review Letters (USA),* 63(17): 1877-1879 (23 Oct 1989). DOE Contract W-31-109-ENG-38.

An unusual loss mechanism has been commonly observed in the high-temperature superconductors in a magnetic field near the zero-field transition temperature T_c. The resistive transitions associated with this loss in highly *c*-axis-oriented $Tl_2Ba_2CaCu_2O_x$ thin films are presented as a function of field perpendicular to the *c* axis, for the current *both perpendicular and parallel to the field.* The data for these orientations are essentially the same over a span of 5 orders of magnitude below the normal-state resistance. Since the *macroscopic* Lorentz force is zero for the current parallel to the magnetic field, it can play, at most, a significantly reduced role in this loss mechanism, and our results seriously question any explanation of these losses based on magnetic flux motion.

8035 Microscopic studies of the optical spectra of $YBa_2Cu_3O_7$. Maksimov, E.G. (P. N. Lebedev Physical Institute, Academy of Sciences, Moscow B 133, Union of Soviet Socialist Repulics (SU)— Brookhaven National Laboratory, Department of Physics, Upton, New York 11973); Rashkeev, S.N.; Savrasov, S.Y.; Uspenskii, Y.A.;. *Physical Review Letters (USA),* 63(17): 1880-1883 (23 Oct 1989).

Microscopic studies of the optical spectra of $YBa_2Cu_3O_7$ have been done using the linear-muffin-tin-orbital (LMTO) method for solving the band-structure problem. Special attention has been paid to the midinfrared and visible spectral range where a number of peculiarities including the large anisotropy of the optical reflectance was observed. It is shown that the overall features of the observed optical spectra can be well explained in the framework of the usual band-structure approach. Moreover, the anisotropy of the reflectance in the *a-b* planes and the positions of the main interband transitions are also in good agreement with available experimental data.

8036 ^{17}O NMR study of local spin susceptibility in aligned $YBa_2Cu_3O_7$ powder. Takigawa, M. (Los Alamos National Laboratory, Los Alamos, New Mexico 87545 (US)); Hammel, P.C.; Heffner, R.H.; Fisk, Z.; Ott, K.C.; Thompson, J.D.;. *Physical Review Letters (USA),* 63(17): 1865-1868 (23 Oct 1989).

^{17}O nuclear-magnetic-resonance spectra are obtained, using uniaxially aligned powder of $YBa_2Cu_3O_7$, and resonance lines from the four inequivalent oxygen sites are clearly distinguished. Principal components of the electric field gradient (EFG) and the shift tensors are obtained in the normal state. Assigning the direction of the largest EFG components of Cu-O bond axes, the anisotropy of the shift suggests that the spin density at the plane O(2,3) and the bridging O(4) sites resides on the p_σ orbitals. The domonant contribution to the spin susceptibility comes from Cu *d* states.

8037 Spin dynamics at oxygen sites in $YBa_2Cu_3O_7$. Hammel, P.C. (Los Alamos National Laboratory, Los Alamos, New Mexico 87545 (US)); Takigawa, M.; Heffner, R.H.; Fisk, Z.; Ott, K.C.;. *Physical Review Letters (USA),* 63(18): 1992-1995 (30 Oct 1989).

We report NMR measurements of the nuclear relaxation rate at all copper and oxygen sites in magnetically aligned powder samples of $YBa_2Cu_3O_7$. Comparison of the oxygen and copper relaxation reveals a characteristic temperature greater than T_c. The copper relaxation rate is enhanced by antiferromagnetic copper spin fluctuations which are undiminished in the superconducting state. The absence of a coherence peak indicates that the superconductive pairing is not of the conventional BCS type.

8038 Properties of sputtered superconducting films of $Bi_2Sr_2CaCu_2O_x$ made by low-temperature *in situ* growth. Kampwirth, R.T. (Materials Science Division, Argonne National Laboratory, Argonne, Illinois 60439 (US)); Andersen, P.H.; McDonald, D.B.; Miller, D.J.; Gray, K.E.; Sungaila, Z.F.; Balachandran, U.; Wagner, A.;. *Applied Physics Letters (USA),* 55(20): 2135-2137 (13 Nov 1989). DOE Contract W-31-109-ENG-38.

Superconducting films of $Bi_2Sr_2CaCu_2O_x$ have been fabricated on single-crystal MgO substrates by a low-temperature *in situ* process. Using a substrate temperature $T_s \approx 645$ °C, metallic films with a superconducting onset of 90–100 K and an extrapolated T_{c0}=56 K have been obtained. X-ray diffraction shows the films to be *c*-axis oriented. Electron microscopy reveals that the films are not significantly smoother than films which were post-annealed at 865 °C, and that some segregation into nonsuperconducting phases had occurred. The exact mechanism by which crystallization and superconductivity occurs at such low temperatures is not yet known, but it can be speculated that the surface atoms are less constrained and thus have a smaller energy barrier to overcome in forming a crystal structure.

8039 Oxygen diffusion and phase transformation in $YBa_2Cu_3O_{7-x}$. Shi, D. (Materials Science Division, Argonne National Laboratory, Argonne, Illinois 60439 (US)); Krucpzak, J.; Tang, M.; Chen, N.; Bhadra, R. *Journal of Applied Physics (USA),* 66(9): 4325-4328 (1 Nov 1989). DOE Contract W-31-109-ENG-38.

Isothermal anneal experiments have been conducted over a wide temperature range from 300 to 900 °C for polycrystalline $YBa_2Cu_3O_{7-x}$ samples in air. The phase transformation and oxygen contents of the annealed samples were studied and determined by x-ray diffraction and iodine titration. Oxygen diffusion coefficients at different temperatures were determined by a novel technique based on direct observation of the oxygen diffusion fronts by polarized light microscopy. The activation energy for the diffusion of oxygen in $YBa_2Cu_3O_{7-x}$ was obtained by an Arrhenius plot of the diffusion coefficients at different temperatures. The tetragonal-to-orthorhombic phase transformation controlled by oxygen diffusion is discussed.

8040 Photoelectric yield measurements of rare-earth trifluorides in the 30–250-eV photon energy range. Bartlett, R.J. (Los Alamos National Laboratory, Los Alamos, New Mexico 87545 (US)); Wieliczka, D.M.; Olson, C.G. *Journal of Applied Physics (USA),* 66(9): 4368-4371 (1 Nov 1989).

The total yield spectra of combinations of rare-earth trifluorides were measured in the 30–250-eV photon energy range to investigate their value as high-efficiency, customizeable photocathode materials. The yield spectra resemble the weighted sum of the absorption spectra of the constituent rare earths, but the amplitude of the yield spectra were compressed relative to the absorption coefficient data due to the large electron escape depths in these materials.

8041 A comprehensive study on the optical properties of thin-film $CuInSe_2$ as a function of composition and substrate temperature. Tuttle, J.R. (Solar Energy Research Institute, 1617 Cole Boulevard, Golden, Colorado 80401 (US)); Albin, D.; Matson, R.J.; Noufi, R. *Journal of Applied Physics (USA),* 66(9): 4408-4417 (1 Nov 1989). DOE Contract AC02-83CH10093.

The absorption coefficient (α) and fundamental transition energies of thin-film $CuInSe_2$ were determined by spectrophotometry in the

near-infrared (NIR) and visible wavelength regions from 500 to 2000 nm for a wide range of compositions. The results suggest a relationship between the constituent specie fluxes and substrate temperature, and the resulting polycrystalline nature of the film which dominates the optical properties. Near-stoichiometric and Cu-rich films appear to crystallize in larger grain sizes in comparison with Cu-poor films, with a $Cu_{2-\delta}Se$ secondary phase at grain boundaries and free surfaces. Correspondingly, significant variations in the absorption coefficient among different film compositions exist in the neighborhood of the band edge. At energies well above the gap, all films behave similarly with α's of $(1–2)\times10^5$ cm^{-1} at 500 nm. Similarly, continuous dispersion curves for the index of refraction have only been derived for single phase Cu-poor material by an iterative technique. The absorption data are substantiated through spectral response simulations that accurately reproduce measured device data. The range of primary and secondary transition energies, respectively, is 0.95–1.01 and 1.17–1.22 eV. These values indicate a valence-band splitting of 0.20–0.24 eV, in good agreement with single-crystal values.

8042 **Preferred orientation effects in coevaporated films of $DyBa_2Cu_3O_{7-x}$ superconductors.** Budhani, R.C. (Department of Applied Science, Brookhaven National Laboratory, Upton, New York 11973 (US)); Xu, Y.; Wiesmann, H.; Ruckman, M.W.; Sabatini, R.L.;. *Journal of Applied Physics (USA)*, 66(10): 4896-4899 (15 Nov 1989). DOE Contract AC02-76CH00016.

Thermal coevaporation has been used to deposit thin films of Dy-Ba-Cu-O compounds on magnesium oxide substrates. The as-deposited films crystallize into a randomly oriented polycrystalline phase on annealing at 900 °C. Further annealing at higher temperatures results in a *c*-axis-oriented material. Effects of the structural changes on the superconducting behavior of the films have been evaluated with resistivity and magnetization measurements. The *c*-axis-oriented films show sharper resistive transition and improved diamagnetic shielding.

8043 **Photoemission study of absorption mechanisms in $Bi_{2.0}Sr_{1.8}Ca_{0.8}La_{0.3}Cu_{2.1}O_{8+\delta}$, $BaBiO_3$, and $Nd_{1.85}Ce_{0.15}CuO_4$.** Lindberg, P.A.P. (Stanford Electronics Laboratories, Stanford University, Stanford, California 94305 (US)); Shen, Z.; Wells, B.O.; Dessau, D.S.; Ellis, W.P.; Borg, A.; Kang, J.;. *Physical Review [Section] B: Condensed Matter (USA)*, 40(13): 8840-8843 (1 Nov 1989). DOE Contract AC03-82ER13000.

Photoemission measurements in the constant-final-state (absorption) mode were performed on three different classes of high-temperature superconductors $Bi_{2.0}Sr_{1.8}Ca_{0.8}La_{0.3}Cu_{2.1}O_{8+\delta}$, $BaBiO_3$, and $Nd_{1.85}Ce_{0.15}CuO_4$ using synchrotron radiation from 20 to 200 eV. Absorption signals from all elements but Ce are identified. The results firmly show that the Bi 6*s* electrons are more delocalized in $BaBiO_3$ than in $Bi_{2.0}Sr_{1.8}Ca_{0.8}La_{0.3}Cu_{2.1}O_{8+\delta}$, in agreement with the results of band-structure calculations. Differences in the absorption signals due to O and Bi excitations between $BaBiO_3$ and $Bi_{2.0}Sr_{1.8}Ca_{0.8}La_{0.3}Cu_{2.1}O_{8+\delta}$ are discussed. Delayed absorption onsets attributed to giant resonances (Ba $4d\rightarrow4f$, La $4d\rightarrow4f$, and Nd $4d\rightarrow4f$ transitions) are also reported.

8044 **Thermal expansivity below 300 K and low-temperature heat capacity of $YBa_2Cu_3O_7$.** Swenson, C.A. (Ames Laboratory, U.S. Department of Energy, Iowa State University, Ames, Iowa 50011 (US)); McCallum, R.W.; No, K.;. *Physical Review [Section] B: Condensed Matter (USA)*, 40(13): 8861-8871 (1 Nov 1989). DOE Contract W-7405-ENG-82.

Thermal expansivities from 1 to 300 K and heat capacities from 1 to 80 K are reported for three ceramic Y-Ba-Cu-O samples. The limiting Debye temperatures, $FTHETA_0$, were found to be 322, 422, and 435 K for samples with (1) a few percent excess CuO, (2) high purity but large, elongated grains, and (3) high purity and small grains, respectively. A similar range of $FTHETA_0$'s for superconducting samples is found in the literature, which suggests an insensitivity of superconductivity in ceramic Y-Ba-Cu-O to lattice properties (that is, to $FTHETA_0$). The expansivity data for each of these samples showed scatter and instability just below T_c and between 180 and 200 K, which, in general but not in detail, may be inherent to ceramic Y-Ba-Cu-O. The expected decrease in the expansivity on warming through T_c was not unambiguously observed. The expansivity data suggest lattice softening below T_c, with, however, normal temperature dependences for the Debye *FTHETA*'s and the Grueneisen parameters γ. The magnitudes and signs of the low-temperature expansivities and γ's are characteristic of two sources for both the low-temperature "electronic" and "anomalous" contributions to the thermodynamic properties. The relatively small values for the lattice γ's correspond to "normal" pressure dependences for the elastic constants of these materials, including the bulk modulus, and support the use of bulk moduli derived from x-ray measurements rather than from ultrasonic experiments.

8045 **Structure and oxygen stoichiometry for the electron-doped cuprate superconductor $Nd_{1.85}Ce_{0.15}CuO_{4-\delta}$.** Kwei, G.H. (Los Alamos National Laboratory, Los Alamos, New Mexico 87545 (US)); Cheong, S.; Fisk, Z.; Garzon, F.H.; Goldstone, J.A.; Thompson, J.D.;. *Physical Review [Section] B: Condensed Matter (USA)*, 40(13): 9370-9373 (1 Nov 1989).

We have determined the structure of the newly discovered electron-doped superconductor $Nd_{1.85}Ce_{0.15}CuO_{4-\delta}$ at 11 and 300 K using high-resolution neutron-powder-diffraction techniques. Both nonsuperconducting oxygenated and superconducting Zr-gettered (T_c=24 K with shielding and Meissner fractions of 30 and 16% at 5 K, respectively) samples were investigated to study the effect of Zr gettering on the crystal structure and oxygen stoichiometry. We find that the structure remains tetragonal (*I4/mmm*), with no evidence for Nd/Ce ordering, for both samples at both temperatures. Structure and oxygen stoichiometry of the oxygenated and Zr-gettered samples remain remarkably similar at both temperatures, the only difference being a slight decrease (but greater than three standard deviations) in the thermal parameters of the rare-earth ions along the *c* axis for the superconducting sample. Thermogravimetric analyses confirm the oxygen stoichiometry determined from the structural refinements.

8046 **Magnetic and resistive measurements of the superconducting critical fields of melt-cast $Ba_{0.65}K_{0.35}BiO_3$.** Kwok, W.K. (Materials Science Division, Argonne National Laboratory, Argonne, Illinois 60439 (US)); Welp, U.; Crabtree, G.W.; Vandervoort, K.G.; Hulscher, R.; Zheng, Y.; Dabrowski, B.; Hinks, D.G.;. *Physical Review [Section] B: Condensed Matter (USA)*, 40(13): 9400-9403 (1 Nov 1989). DOE Contract W-31-109-ENG-38.

The upper and lower critical fields of a melt-cast polycrystalline sample of $Ba_{0.65}K_{0.35}BiO_3$ synthesized by a novel technique are obtained from both resistive and magnetic measurements. The coherence length ξ_{GL}, penetration depth λ_{GL}, and Ginzburg-Landau parameter κ are determined and the size of the specific-heat jump is predicted. The estimated electron-phonon coupling parameter is about 1.

3606 Other Materials

Refer also to citation(s) 6757, 6758, 6797, 7109, 7129, 7130, 7131, 7132, 7133, 7134, 7135, 7137, 7138, 7139, 7177, 7507, 7621, 7883, 7913, 8349

8047 (BNL–43482) **Slow positron defect profiling of silicon epilayers.** Tandberg, E. (University of Western Ontario, London, ON (Canada). Dept. of Physics); Schultz, P.J.; Jackman, T.E.; Denhoff, M.W.; Aers, G.C.; Lynn, K.G.; Nielsen, B. Brookhaven National Lab., Upton, NY (USA). 1988. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-8808122–18: 8. international conference on positron annihilation, Gent (Belgium), 29 Aug - 3 sep 1988). Order Number DE90003958. Available from NTIS, PC A02/MF A01 - OSTI.

Over the last decade, positrons have been used as a probe to non- destructively study and depth profile defects in dilute concentrations (parts per million) in solids. Only recently have positrons been used to profile buried defects in ultra-thin epitaxial layers of semiconductors. We will discuss recent results which involve the modeling of defects and electric fields in homoepitaxial layers of silicon grown by molecular beam epitaxy (MBE) on a Si(100) substrate. We will also discuss some of the limitations of the modelling technique and future prospects. 6 refs., 1 fig.

8048 (CONF-891119–30) **New electrically conducting solids based on nickel(II) - bis (1,3-dithiole-2-thione-4,5-diselenolate).** Kini, A.M.; Beno, M.A.; Budz, S.; Wang, H.H.; Williams, J.M. Argonne National Lab., IL (USA). [1989]. 12p. Sponsored by U.S. DOE Energy Research. DOE Contract W-31109-ENG-38. From Materials Research Society fall meeting; Boston, MA (USA); 27 Nov - 2 dec 1989. Order Number DE90003788. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Electrochemical oxidation of the metal-organic complex, nickel(II) - bis(1,3 - dithiole - 2 - thione - 4,5 - diselenolate) $[Ni(dsit)_2]^{2-}$, yields highly conducting salts, in which the stoichiometry and packing arrangement depends critically on the site of the counter-cations incorporated. Smaller counter-cations, e.g., tetramethylammonium and tetramethylphosphonium ions, yield salts with a 1:2 cation N:$(dsit)_2$ stoichiometry, while the larger tetraethylammonium ion yields a salt with 2:2 stoichiometry. In both these salts, the $Ni(dsit)_2$ units occur as tightly bound dimers, in which coordination geometry of nickel is a unique, but not unprecedented square-pyramidal type. Moreover, the packing arrangement of $[Ni(dsit)_2]_2$ dimer units in both (Me_4N) $[Ni(dsit)_2]_2$ and (Me_4P) $[Ni(dsit)_2]_2$ is κ-type, similar to that found in the organic superconductor with the highest-known T_c (10.4 K), κ-$(BEDT\text{-}TTF)_2Cu(NCS)_2$. Both these salts possess good room temperature conductivities (σ_{rt} = 36 and 19 S · cm^{-1} respectively), but the temperature dependence of their conductivities is characteristic of semiconductors with small bandgaps (E_g = 0.11 and 0.13 eV respectively). The 2:2 salt $(Et_4N)_2[Ni(dsit)_2]_2$, on the other hand, has a substantially lower room temperature conductivity, about six orders of magnitude smaller than that of the 1:2 salts. 19 refs., 3 figs., 3 tabs.

8049 (CONF-891119–41) **Ion beam annealing of Si co-implanted with Ga and As.** Withrow, S.P. (Oak Ridge National Lab., TN (USA)); Holland, O.W.; Pennycook, S.J.; Pankove, J.; Mascarenhas, A. Oak Ridge National Lab., TN (USA). Nov 1989. 8p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. From Materials Research Society fall meeting; Boston, MA (USA); 27 Nov - 2 dec 1989. Order Number DE90004297. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Ion beam annealing of amorphous Si(100) layers formed by co-implantation of overlapping Ga and As distributions is studied. Annealing was done using 750 keV Si^+ ions with the Si substrate held at 300°C. The samples were characterized using 2.0 and 5.0 MeV He^+ backscattering/channeling as well as by transmission electron microscopy (TEM). Crystallization of the amorphous Si layer occurs during irradiation via solid-phase-epitaxial growth without impurity precipitation or segregation. Both the Ga and As are nearly substitutional in the Si lattice, even at concentrations in excess of 7 at. % for each species. These results are attributed to compensation effects, most likely through ion pairing of the electrically-attractive dopants. 11 refs., 3 figs.

8050 (CONF-900102–2) **Toughening behavior and interfacial properties of fiber-reinforced ceramic composites.** Hsueh, Chun-Hway (Oak Ridge National Lab., TN (USA)). Oak Ridge National Lab., TN (USA). [1989]. 31p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. From 13. energy-sources technology conference and exhibition; New Orleans, LA (USA); 14-18 Jan 1990. Order Number DE89015351. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Toughening of ceramics by incorporating strong fibers has become an established technology, resulting in the creation of a new generation of tough ceramic composites. This toughening effect is primarily due to bridging of the crack surfaces by intact fibers when the composite is subjected to tension. The fiber bridging mechanisms, which are contingent upon the stress transfer phenomena between the fiber and the matrix, are reviewed in this paper. The critical role of the properties at the fiber/matrix interface in controlling the stress transfer phenomena is examined. Finally, evaluations of the interfacial properties of the composite by the indentation technique and the corresponding analysis are presented. 39 refs., 8 figs.

8051 (CONF-8908191–1) **New organic synthetic metals derived from BEDT-TTF, $Ni(dsit)_2$ and BEDO-TTF.** Beno, M.A.; Kini, A.M.; Geiser, U.; Wang, H.H.; Carlson, K.D.; Williams, J.M. Argonne National Lab., IL (USA). [1989]. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract W-31109-ENG-38. From 1. ISSP international symposium on the physics and chemistry of organic superconductors; Tokyo (Japan); 27-30 Aug 1989. Order Number DE90003793. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Three strategies have been employed by us to synthesize new organic synthetic metals and superconductors. On the basis of structure-property correlations derived for the β-$(BEDT\text{-}TTF)_2X$ salts, new charge transfer salts of BEDT-TTF with large, polarizable anions have been synthesized. The occurrence of molecular dimers has been engineered into salts of the new organic acceptor molecule, $Ni(dsit)_2$ [bis (4,5 -diselenolate -1,3-dithiole-2-thione) nickelate], to synthesize salts with acceptor packing similar to the donor packing in κ-$(BEDT\text{-}TTF)_2Cu(SCN)_2$. Finally, two charge transfer salts of bis(ethylenedioxy)tetrathiafulvalene, BEDO-TTF, namely $(BEDO\text{-}TTF)_2AuBr_2$ and $(BEDO\text{-}TTF)_2AuI_2$ have been synthesized. The $AuBr_2^-$ salt, the first BEDO-TTF salt to be structurally characterized, is semiconducting below 263 K, while the AuI_2^- salt shows metallic conductivity to low temperatures. 10 refs., 3 figs.

8052 (CONF-8910319–1) **On the choice of trial function in theoretical calculations of the thermal conductivity.** Pettersson, S. (Tennessee Univ., Knoxville, TN (USA). Dept. of Physics and Astronomy). Oak Ridge National Lab., TN (USA); Tennessee Univ., Knoxville, TN (USA). Dept. of Physics and Astronomy. Oct 1989. 18p. Sponsored by U.S. DOE Energy Research; University of Tennessee. DOE Contract AC05-84OR21400. From 21. international thermal conductivity conference; Lexington, KY (USA); 15-18 Oct 1989. Order Number DE90001733. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The dispersion relations for 17 alkali halides are calculated throughout the entire Brillouin zone with a deformation dipole model. The linearized Boltzmann equation, including only three-phonon scattering processes, is solved by a variational method. Several trial functions and linear combinations are tested. Separate trial functions are assumed for the acoustic and optic branches, respectively, which gives an improved estimate of the importance of optic phonons as heat carriers. The amount of heat carried by optic phonons differ greatly among the investigated crystals, from 2% up to 34%. The introduction of linear combination of trial functions increases the thermal conductivity values by 10-300%. 28 refs., 1 fig., 3 tabs.

8053 (DOE/ER/13507–5) **Synthesis and analysis of novel polymers with potential for providing both high permselectivity and permeability in gas separation applications: Progress report, December 1988–November 1989.** Koros, W.J.; Paul, D.R. Texas Univ., Austin, TX (USA). Dept. of Chemical Engineering. 28 Nov 1989. 7p. Sponsored by U.S. DOE Energy Research. DOE Contract FG05-86ER13507. Order Number DE90003907. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

During the first eight months of project support under our renewal proposal, we have achieved the following important experimental, analytical and publication objectives consistent with our project goal to develop advanced materials for gas separation membrane applications. Synthesized and characterized additional polycarbonate materials beyond those specified in our original proposal to test ideas developed in the course of the work with the originally proposed polycarbonate materials. Completed synthesis and characterization of the originally-proposed polysulfones in our renewal proposal. Also synthesized and begun characterization of additional polysulfone materials beyond those proposed in the renewal proposal to test ideas developed in the course of the work with the originally proposed materials. Began work to synthesize the systematic family of polyesters described in our renewal proposal. Three new papers have appeared in print and we have prepared 4 new manuscripts and given 5 presentations at technical meetings. This brings the total to 11 publications produced under our three-and-a-half years of DOE support.

8054 (FhG-IWM-W–7/89) **Delamination growth and buckling in an orthotropic strip.** Madenci, E. Fraunhofer-Institut fuer Werkstoffmechanik, Freiburg im Breisgau (Germany, F.R.). May 1989. 32p. Order Number DE90728816. Available from NTIS (US Sales Only), PC A03/MF A01.

This study presents an analytical solution to the problem of delamination growth and buckling in a layered plate. Delamination

growth and buckling is a commonly observed failure mode in laminated structures; this type of failure mode may cause structural degradation or stiffness reduction and leads ultimately to premature failure at stresses well below the design levels for an undamaged laminate. Under compression loading the nature of the delamination response which involves the interaction of delamination growth and buckling is addressed by employing the three-dimensional equations of elastic stability. Solutions to the problem of an orthotropic plate with a through-width delamination subjected to uniaxial compression is obtained by using mathematical techniques appropriate for mixed boundary value problems. (orig.).

8055 (FSJ–8901, pp. 123-126) **Oxidation of fine particles of pitch prepared by spray technique.** Torikai, Naochika (Yokohama National Univ., Faculty of Engineering, Yokohama, Japan); Meguro, Takeshi; Yamada, Jun; Wakasa, Tsutomu. Fuel Society of Japan, Tokyo (Japan). 1 Oct 1987. (In Japanese). In *Proceeding of the 24th Coal Science Conference 1987.* Order Number DE90724841. Available from NTIS (US Sales Only), PC A13.

Reformed pitch was sprayed from nozzles at a heating condition to prepare raw material for carbon material manufacturing which is in turn, produced to high density and high strength carbon products through forming and sintering. This study determined the insolubilizing condition by oxidizing through heating in oxygen atmosphere to insolubilize pitch particles prepared through heating and spraying and the influence of reaction mechanism and insolubilization on the carbide structure. From the relation between insolubilizing temperature and oxygen content, oxygen content increased and condensation and polymerization proceeded with the increase of the insolunilizing temperature, indicating that oxygen related to the insolubulization. The change of functional group containing oxygen was clearly confirmed by the insolubilization from the measurement with FTIR(Fourier transformation infrared absorption spectrometry) spectrum, indicating that there is a close relation between the oxygen absorption accompanied by oxidation and the insolubilization. 1 ref., 5 figs.

8056 (INIS-mf–12036) **HTR concrete experiments - high-temperature strength experiments. Final report.** Diederichs, U. Technische Univ. Braunschweig (Germany, F.R.). Inst. fuer Baustoffe, Massivbau und Brandschutz; Hochtemperatur-Reaktorbau G.m.b.H., Mannheim (Germany, F.R.). Jan 1989. 60p. (In German). Order Number DE90732381. Available from NTIS (US Sales Only), PC A04/MF A01.

It is reported on high-temperature strength investigations on unsealed HTR concrete samples of basalt concrete and Rhenish gravel concrete. These investigations had become necessary, because only temperatures up to 300°C have been considered in the framework of the previous R + D concrete programme, but the consideration of hypothetic breakdowns requires to have corresponding strength and deformation data at least up to temperatures of 600°C available. The tests were carried out on a high-temperature test stand on cylindrical test specimens of a diameter of 8 cm and a length of 24 cm. Three different courses of experiment were realized: (1) 'slow' heating with a constant heating rate of 5 K/h, (2) 'rapid' heating with a constant heating rate of 20 K/h, (3) 'stepped' heating with the samples heated up to 120°C at 5 K/h, then kept at this temperature for approx. 24 h and finally heated up to 400, 500 resp. 600°C at 20 K/h. The samples were installed in the testing machine with a low load required. After installing the samples were at first loaded and relieved three times with max. 15 N/mm^2 at room temperature, thus determining the modulus of elasticity. Then a creep stress of 15 N/mm^2 was applied and the heating up to 400°C, 500°C resp. 600°C took place according to the temperature programmes mentioned before. After reaching the corresponding test temperature the samples were thermally homogenized up to 2 hours. Finally the modulus of elasticity was determined in a hot state by loading and relieving the samples three times. (orig./MM).

8057 (KFK–4414) **Causes of defects and accuracy of structure reproduction in deep-etch X-ray lithography using synchrotron radiation.** Mohr, J.; Ehrfeld, W.; Muenchmeyer, D. Kernforschungszentrum Karlsruhe G.m.b.H. (Germany, F.R.). Inst. fuer Kernverfahrenstechnik; Karlsruhe Univ. (T.H.) (Germany, F.R.). Fakultaet fuer Maschinenbau. Jul 1988. 103p. (In German). Order Number DE90732695. Available from NTIS (US Sales Only), PC A06/MF A01.

Dissertation submitted by J. Mohr.

Under the LIGA process plastic microstructures with extraordinarily high aspect ratios are produced by means of deep-etch synchrotron radiation lithography. These microstructures are used as templates for the fabrication by electroforming of metallic microstructures. The several hundred micrometer thick resist layers required in the process are polymerized directly on a metal base plate using a methacrylate based resin. This provides sufficient stability during the production process and also a reliable plating base for the electrodeposition of the metal. Perfect adhesion of micron-sized microstructures on a smooth surface can be achieved if the polished metal surface is sputtered with titanium and chemically oxidized afterwards. Alternatively it is also possible to add an internal adhesion promoter like methacryl oxypropyl trimethoxy silane to the resin. By means of this adhesion promoter chemical bonding between the metal surface and the polymer is achieved. (orig.).

8058 (LBL–27886) **Heteroepitaxy of GaAs on Si: Methods to decrease the defect density in the epilayer.** Liliental-Weber, Z.; Weber, E.R.; Washburn, J. Lawrence Berkeley Lab., CA (USA). Sep 1989. 10p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00098. (CONF-890946–3: 3. meeting on defect recognition and image processing in semiconductors (DRIP-3), Yokohama (Japan), 17-22 Sep 1989). Order Number DE90004028. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

In this paper, the fundamental mechanisms of defects formation and procedures used to improve the structural quality of GaAs grown on Si are discussed. Patterned growth, strained-layer superlattices, and proper thermal cycling are promising approaches to help achieve high quality GaAs layers grown on Si substrates. 55 refs., 9 figs.

8059 (OH/RD–88-196-K) **Alexander GS [generating station] tailrace piers Cameron Falls GS [generating station] main dam concrete investigation.** Mc Colm, E.J. Ontario Hydro Research Div., Toronto, ON (Canada). 28 Oct 1988. 23p. (MICROLOG–89-04675). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

An investigation into the deterioration of the concrete in the tailrace piers at Alexander Generating Station (GS) and the sluiceway piers at Cameron Falls GS established that the primary cause of deterioration is freeze-thaw cycling of the concrete in a saturated state. It was also determined that a very poor bond exists between a repair slab and the original concrete of the east gravity section at Cameron Falls GS. Consideration should be given to repair the tailrace piers at Alexander GS and the sluiceway piers, the east abutment pier and the gravity section at Cameron Falls GS. 13 figs., 2 tabs.

8060 (OH/RD–88-251-K) **Cherrywood TS [transmission station] to Leaside TS [transmission station] 230 kV TL [transmission line] foundation investigation.** Tsang, R.H.K. Ontario Hydro Research Div., Toronto, ON (Canada). 8 Dec 1988. 7p. (MICROLOG–89-04317). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

The design of steel pole foundations requires an estimate of the soil deformation modulus. A statistical analysis was performed to correlate the initial loading deformation modulus, E, from prebored pressuremeter tests, with the N-value obtained from standard penetration tests in granular soils. 4 refs., 3 figs.

8061 (OH/RD–99-320-K) **Selection of uplift coefficients for uplift design of transmission tower foundations.** Craggs, C.B.H.; Tsang, R. Ontario Hydro Research Div., Toronto, ON (Canada). 27 Jan 1989. 37p. (MICROLOG–89-04572). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy,

Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

This report presents and discusses enhancements to the Ku theory for the uplift capacity of augered pier foundations in granular soils. The Ku theory was proposed by Meyerhof and Adams in 1968 and was supported by a limited range of field and laboratory data. In this paper, a thorough review of the uplift load test data now available in the literature is made. The data are analyzed by the Ku-theory to yield correlations between Ku and the depth-to-diameter ratio of foundations. Gaps in the data are supplemented by further full-scale tests and laboratory model tests. The statistical parameters for Ku have been derived from all the data. A probability-based method for the uplift design of augered footings is proposed, incorporating these statistical Ku parameters. 35 refs., 6 figs., 12 tabs.

8062 (PNL-SA–17227) **Design, characterization, and optical properties of phosphazene-based polymers.** Exarhos, G.J.; Samuels, W.D. Pacific Northwest Lab., Richland, WA (USA). Nov 1989. 6p. Sponsored by U.S. DOE Energy Research. DOE Contract AC06-76RL01830. (CONF-891117–12: 34. conference on magnetism and magnetic materials, Boston, MA (USA), 28 Nov - 1 dec 1989). Order Number DE90004111. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Physical properties intrinsic to linear inorganic polymer systems can be modified through replacement of chemical groups external to the chain backbone. This substitution also perturbs chemical bonding along the chain which can further influence polymer properties. Several phosphazene polymers deposited as thin dielectric films exhibit extended ultraviolet transmission. Second harmonic generation (SHG) has been observed in these polymers as well as in cyclic polymer precursors. The relative magnitude of SHG is found to correlate both with the nature of the substitutional group and molecular conformation. Influence of these parameters on substrate-film adhesion and measured optical properties is discussed in terms of substitutional group electronegativity, and electronic charge localization in the polymer chain which is probed using molecular spectroscopic techniques. 9 refs., 3 figs.

8063 (SAND–89-1534C) **Fundamental issues in heteroepitaxy (condensed from the DOE panel report).** Peercy, P.S. Sandia National Labs., Albuquerque, NM (USA). 1989. 12p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-891119–34: Materials Research Society fall meeting, Boston, MA (USA), 27 Nov - 2 dec 1989). Order Number DE90003980. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The Department of Energy's Council on Materials Science convened a Panel charged with assessing the present scientific understanding of epitaxial growth and identifying fruitful research opportunities in this area. The Panel, chaired by Paul S. Peercy, a member of the Department of Energy's Council on Materials Science and of the Solid State Sciences Committee, was composed of scientists in materials science, physics, and chemistry from academia, government labs and industry. Panel members were: Ernst G. Bauer, Brian W. Dodson, Daniel J. Ehrlich, Leonard C. Feldman, C. Peter Flynn, Michael W. Geis, James P. Harbison, Richard J. Matyi, Pierre M. Petroff, Paul S. Peercy, Julia M. Phillips, Gerald B. Stringfellow and Andrew Zangwill. The Panel met in January, 1989; its activities were supported by the Materials Sciences Division of Basic Energy Sciences. Deliberations emphasized artificially structured materials and resulted in a Panel Report which has been submitted to the Journal of Materials Research. With permission from the Department of Energy, this article excerpts from the report. 32 refs., 7 figs.

8064 (SAND–89-1822C) **Characterization of B and N implanted fused silica.** Arnold, G.W.; Brow, R.K.; Carr, M.J.; Barbour, J.C. Sandia National Labs., Albuquerque, NM (USA). [1989]. 11p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-891119–40: Materials Research Society fall meeting, Boston, MA (USA), 27 Nov - 2 dec 1989). Order Number DE90004198. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The implantation of B and N into fused silica can result in chemical incorporation into the glass with a consequent larger increase in refractive index than is possible due to volume compaction alone. B implantation produces anomalously large concentrations of oxygen-vacancy defects which aid in the accommodation of B into a borosilicate layer. N implants can result in unreacted N accumulations in addition to N incorporated into an Si-oxynitride layer. The unreacted N can also be incorporated by implantation damage (e.g., Si, Ar, Kr) – before or after N implantation – which provides additional occupancy sites. These results are important with respect to the use of implantation-produced waveguides for optoelectronic devices. 13 refs., 5 figs.

8065 (SAND–89-2090) **SI deposition rates in a two-dimensional CVD [chemical vapor deposition] reactor and comparisons with model calculations.** Breiland, W.G.; Coltrin, M.E. Sandia National Labs., Albuquerque, NM (USA). Oct 1989. 46p. Sponsored by U.S. DOE Energy Research. DOE Contract AC04-76DP00789. Order Number DE90005003. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Deposition rates are presented for silicon from silane in a helium carrier gas using a tubular CVD reactor with a two-dimensional flow geometry. Measured surface-temperature profiles, inlet gas velocities, total pressures, and silane/helium concentrations are reported, providing exact boundary conditions that can be used in a two-dimensional numerical CVD model. Comparisons are made between this data and two variations of a model by Coltrin, Kee, and Miller in which different empirical expressions for the silane and disilane reactive sticking coefficient are used.

8066 (SAND–89-8224) **Evaluation of potential cold x-ray shield materials tested on Proto II.** Lucas, J.P. Sandia National Labs., Livermore, CA (USA). Dec 1989. 46p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DR00789. Order Number DE90004348. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Several composite materials were irradiated with cold x-rays of photon energies of 1 and 3 keV line radiation generated by imploding Ne and Ar gas using the Proto II accelerator. The materials were exposed to fluences of up to 60 cal/cm^2. Continuous reinforced carbon phenolic and carbon-carbon composites and an inorganic rigid SiO_2 fiber-Al_2O_3 fiber composite were tested. Examination of the irradiated surfaces of all materials revealed varying degrees and types of damage with fluences levels. The surface of irradiated reinforced carbon phenolic (RCP) composite was characterized by blowoff debris and melting of the matrix resin. The melt depth of RCP materials increased as the fluence increased. Surface fibers of irradiated inorganic fibrous composite (IFC) exhibited severe melting, but the extent of surface blowoff debris was considerably less than that of RCP materials. Both melting and blowoff were minimal on the surface of irradiated reinforced carbon-carbon (RCC) composite, even at high fluence levels. Interior spall and delamination were seen in exposed RCP material above an apparent threshold fluence of ~15 cal/cm^2. However, no internal structural damage was observed in either RCC or the IFC composites at the maximum fluence levels tested of 9 and 17 cal/cm^2, respectively. Of the composite materials tested, RCC appeared to be the most attractive material for cold x-ray shielding based on its resistance to debris blowoff from vaporization, surface melting and interior structural damage. 9 refs., 16 figs.

8067 (UCRL–21193) **Silicon membrane formation.** Hunt, C.E. Lawrence Livermore National Lab., CA (USA). May 1989. 6p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. Order Number DE90003022. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Experiments in the formation of silicon membranes by the use of electrochemical and nonelectro-activated chemical etching have been performed. The starting material in the experiments is MOS-grade Si wafers. Application of the rotating disc (electrode) to the etch process has been included. The results have shown that isotropic chemical thinning can benefit from the rotating disc system and that some electrochemical etching techniques can benefit over normal turbulent agitation methods. The experiments and results are described.

8068 (UCRL–21234) **Development of low density silica aerogel as a capture medium for hyper-velocity particles.** Hrubesh, L.W. Lawrence Livermore National Lab., CA (USA). 1 Oct

1989. 23p. Sponsored by National Aeronautics and Space Administration. DOE Contract W-7405-ENG-48. Order Number DE90003990. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The objective of this study is to develop micro-porous silica aerogel glass with optimal properties for its potential use as a capture medium of hyper-velocity particles. The important properties for this application are identified as ultra-low bulk density (i.e. < 0.1 gm/cc), high transparency to visible light, and purity (absence of organic and inorganic contaminants). Our approach is to expand on our existing knowledge and experience concerning sol-gel chemistry and the extraction technology which we now use to routinely produce clear silica aerogel monoliths at densities higher than 0.1 gm/cc. We expect to push the existing technology toward ultra-low density aerogels and identify any limitations impeding the development of this material with optimal properties for the particle capture application. 3 refs., 10 figs.

8069 **Multilayers: Synthesis, properties and non-electric applications.** Materials Research Society symposium proceedings - volume 103. Barbee, T.W. Jr. (Lawrence Livermore National Lab., CA (USA)); Spaepen, F.; Greer, L. 365p. Materials Research Society, Pittsburgh, PA (1988). (CONF-8711143–: Symposium on multilayers: synthesis, properties and nonelectronic applications, Boston, MA (USA), 30 Nov - 4 dec 1987).

The symposium on Multilayers: Synthesis, Properties and Non-Electronic Applications at which the papers included in this volume were presented, was organized because this is one of the most rapidly expanding areas of solid state science. This growth draws on significant advances in a number of other scientific and technological arenas. In particular, thin-film deposition techniques have in the past two decades progressed to the point that it is now possible reproducibly to prepare multilayer structures of high perfection relative to superlattice characteristics, individual layer structures, and interfacial structure. It is also important to recognize that the broad range of sophisticated and sensitive characterization tools and approaches that are now available have been central to the rapid advance of multilayer research. It is now clear that these new materials can be synthesized with structures allowing the scientific investigation of microstructure sensitive physical phenomena, and the optimization of the properties of technologically useful materials. In summary, multilayer structure research and technology represents a significant part of the forefront of what may be termed Microstructure Engineering.

8070 **Tungsten-carbon multilayer system studied with x-ray scattering.** Kortright, J.B. (Lawrence Berkeley Lab., CA (USA)); Denlinger, J.D. pp. 365 of Multilayers: Synthesis, properties and non-electric applications. Barbee, T.W. Jr.; Spaepen, F.; Greer, L. Materials Research Society, Pittsburgh, PA (1988). DOE Contract AC03-76SF00098. (CONF-8711143–: Symposium on multilayers: synthesis, properties and nonelectronic applications, Boston, MA (USA), 30 Nov - 4 dec 1987).

The tungsten-carbon multilayer system has been studied using x-ray scattering techniques as a function of multilayer period and annealing. Grazing incidence x-ray scattering shows that interatomic arrangements in the W-rich layers depend strongly on their proximity to the interface with the C-rich layers. Amorphous interface layers are stabilized by intermixing of W and C during deposition into local structures similar to those in the tungsten carbides. Further intermixing and structural relaxation in the amorphous state occurs on annealing these structures. This interatomic structural interpretation is consistent with trends in the observed x-ray optical properties.

8071 **Photon-controlled growth of multilayered structures.** Lowndes, D.H. (Oak Ridge National Lab., TN (USA)); Geohegan, D.B.; Eres, D.; Mashburn, D.N.; Pennycook, S.J. pp. 365 of Multilayers: Synthesis, properties and non-electric applications. Barbee, T.W. Jr.; Spaepen, F.; Greer, L. Materials Research Society, Pittsburgh, PA (1988). DOE Contract AC05-84OR21400. (CONF-8711143–: Symposium on multilayers: synthesis, properties and nonelectronic applications, Boston, MA (USA), 30 Nov - 4 dec 1987).

Pulsed ArF excimer laser (193 nm) photolysis has been used to deposit entirely amorphous and mixed amorphous/polycrystalline superlattice structures containing Si, Ge and Si_3N_4. High resolution in situ optical reflectivity measurements were used to monitor and/or control deposition. Transmission electron microscope cross-section views demonstrate that amorphous superlattice structures having highly reproducible layer thicknesses (from about 50 to several hundred A), and sharp interlayer boundaries, can be deposited at low substrate temperatures under laser photolytic control.

8072 **Glancing angle EXAFS studies of tungsten-carbon multilayers.** Lamble, G.M. (North Carolina State Univ., Raleigh, NC (USA)); Sayers, D.E.; Heald, S.M.; Ziegler, E. pp. 365 of Multilayers: Synthesis, properties and non-electric applications. Barbee, T.W. Jr.; Spaepen, F.; Greer, L. Materials Research Society, Pittsburgh, PA (1988). DOE Contract AC02-76CH00016;AS05-80ER10742. (CONF-8711143–: Symposium on multilayers: synthesis, properties and nonelectronic applications, Boston, MA (USA), 30 Nov - 4 dec 1987).

Results are presented from glancing angle EXAFS studies of three tungsten-carbon multilayer systems, of different W/C thickness ratios, by monitoring the fine structure above the tungsten L3-edge. The purpose of the investigation was to determine the structural changes occurring in the multilayer as a result of moderate annealing. Surprisingly, dramatic changes are observed in the structural environment of the W atoms as a result of heating to temperatures as low as 350^{0}C for 3 hours. It is found that, when the W layer is sufficiently thick, and the W/C layer thickness favorable, W_2C is preferentially formed and crystallization is extensive. The experiment demonstrates the suitability of the EXAFS technique for the study of multilayer systems since contribution to the signal from the interface is significant and the phenomenon is not dependent on the existence of long range order.

8073 **A wavelength streak camera.** McConaghy, C. (Lawrence Livermore National Lab., CA (USA)); Koo, J. pp. 262 of Optoelectronic materials, devices, packaging, and interconnects II. McWright, G.M.; Wojtunik, H.J SPIE Society of Photo-Optical Instrumentation Engineers, Bellingham, WA (1988). (CONF-8809111–: Optoelectronic materials, devices, packaging, and interconnects II, Boston, MA (USA), 6-10 Sep 1988).

The authors demonstrate the recording of 8 Ghz electrical signals by optically encoding time into wavelength and deflecting, by means of a diffracting grating, the optical signal across a readout array. The experiments were performed at 820 nm and show promise for circumventing the material dispersion in fibers at this wavelength to allow propagation of high bandwidth microwave signals (up to 10 Ghz) over 1 km distances.

8074 **Relaxation of metastable semiconductor strained-layer structures by plastic flow.** Dodson, B.W. (Sandia National Labs., Albuquerque, NM (USA)); Tsao, J.Y. pp. 365 of Multilayers: Synthesis, properties and non-electric applications. Barbee, T.W. Jr.; Spaepen, F.; Greer, L. Materials Research Society, Pittsburgh, PA (1988). DOE Contract AC04-76DP00789. (CONF-8711143–: Symposium on multilayers: synthesis, properties and nonelectronic applications, Boston, MA (USA), 30 Nov - 4 dec 1987).

The relaxation of misfit strain in metastable structures by plastic flow is described using a continuum model based on Haasen's picture of plastic flow in bulk diamond-phase semiconductors and the concept of excess stress. This model provides a unified explanation of the equilibrium critical thickness, the relaxation behavior of metastable strained-layer structures, and the metastable critical thicknesses reported in many semiconductor strained-layer geometries.

8075 **Characterization of new focus projection and scan (FPS) vidicons for scientific imaging applications.** Yates, G.J. (Los Alamos National Lab., Los Alamos, NM (US)); Jaramillo, S.A. vp of High speed photography, videography, and photonics V. Johnson, H.C SPIE Society of Photo-Optical Instrumentation Engineers, Bellingham, WA (1987). (CONF-8708231–: High speed photography, videography, and photonics V, San Diego, CA (USA), 17-19 Aug 1987).

Several new photoconductors now commercially available as targets in Type 7803 Focus Production and Scan (FPS) electrostatically focused vidicons are characterized for use as radiometric sensors in transient illumination and single frame applications. These include Saticon (Se + As + Te), Newvicon (AnSe), Pasecon (CdSe), and Plumbicon (PbO). Samples from several domestic and foreign manufacturers evaluated for photoconductive response time

and responsivity at selected narrow wavelength bands, including 410 nm, 560 nm, and 822 nm. These data are compared with performance data from older target materials including Sb_2S_3 and silicon. The effect of bias lighting on sensitivity and transfer curve slopes for single-event pulsed light stimulas are presented. Dynamic range and saturation limits as functions of beam aperture, target voltage, and filament current are also discussed.

8076 **Time-resolved and microstructural studies of solidification in undercooled liquid silicon.** Lowndes, D.H. (Oak Ridge National Lab., Oak Ridge, TN (US)); Pennycook, S.J.; Wood, R.F.; Jellison, G.E. Jr.; Withrow, S.P. pp. 763 of Fundamentals of beam-solid interactions and transient thermal processing. Aziz, M.J.; Rehn, L.E.; Stritzker, B. Materials Research Society, Pittsburgh, PA (1988). DOE Contract AC05-84OR21400. (CONF-8711126--: Symposium on fundamentals of beam-solid interactions and transient thermal processing, Boston, MA (USA), 30 Nov - 3 dec 1987).

Nanosecond resolution visible (633 nm) and near-infrared (1152 nm) reflectivity measurements have been used, together with transmission electron microscopy (TEM), to study pulsed KrF (248 nm) laser melting and subsequent solidification of thick (190-410 nm) amorphous (a) silicon layers. The measurements cover the entire laser energy density (E_{lots}) range between the onset of melting (~0.12 J/cm^2) and the completion of epitaxial crystallization (~1.1 J/cm^2). Four distinct E_{lots}-regimes of melting and solidification are found for the 410-nm thick a-Si layers. The optical and TEM measurements suggest that flakes are the crystallization events that initiate XC, and that lateral heat flow (parallel to the sample surface) must be taken into account in order to understand flake formation. Results of new two-dimensional (2-D) model calculations of heat flow and solidification are presented. These calculations confirm the importance of 2-D heat flow and crystallite growth early in the solidification process.

8077 **Sputtering of Au, CsI and $LiNbO_3$ by multiply charged Ar ions.** Weathers, D.L. (California Inst. of Tech., Pasadena, CA (USA). Div. of Physics, Mathematics, and Astronomy); Tombrello, T.A.; Prior, M.H.; Stokstad, R.G.; Tribble, R.E. *Nuclear Instruments and Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms (Netherlands),* 42(3): 307-316 (Jul 1989). DOE Contract AC03-76SF00098;FG05-86ER40256. DMR-86-15641.

We have bombarded targets of CsI, $LiNbO_3$, and Au with 48, 48, and 60 keV Ar^{q+} ions, respectively, for q = 4, 8, and 11. To look for any possible ejection mechanisms related to the primary charge state q of the projectile, we have examined the total (neutral plus ionic) differential angular sputtering yields and total integrated sputtering yields as a function of q. Our measurements were made using a collector technique: sputtered material was captured on foils surrounding the target, which were subsequently analyzed using heavy ion Rutherford backscattering spectroscopy to determine angular distributions; total sputtering yields were obtained from the angular distributions. No significant variation was observed in the yield from the Au target, but slight ($\simeq$ 10%) enhancements in the total yields from the insulating targets were measured as the projectile charge state was increased from 4+ to 11+. (orig.).

8078 **Electronic structure of dangling and floating bonds in amorphous silicon.** Biswas, R. (Department of Physics and Microelectronics Research Center, Iowa State University, Ames, Iowa 50011 (USA)—Ames Laboratory-United States Department of Energy, Iowa State University, Ames, Iowa 50011 (USA)); Wang, C.Z.; Chan, C.T.; Ho, K.M.; Souk *Physical Review Letters (USA),* 63(14): 1491-1494 (2 Oct 1989). DOE Contract W-7405-ENG-82.

The electronic structure of amorphous silicon models has been calculated with the tight-binding parameters of Chadi. An energy gap of ~1.0 eV is obtained for a fully four-coordinated model, whereas gap states occur for models with coordination defects. Dangling-bond gap states are well localized on the three-coordinated site. Floating bonds lead to considerably less localized gap states with wave-function amplitudes on the neighbors of the five-coordinated atom. The hyperfine splittings of these coordination defects are calculated and compared to experiment.

8079 **Elastic constants of sodalite $Na_4Al_3Si_3O_{12}Cl$.** Li, Z. (Materials Science Division, Argonne National Laboratory, Argonne, Illinois 60439 (US)); Nevitt, M.V.; Ghose, S. *Applied Physics Letters (USA),* 55(17): 1730-1731 (23 Oct 1989). DOE Contract W-31-109-ENG-38.

The elastic stiffness constants of sodalite $Na_4Al_3Si_3O_{12}Cl$ (cubic, a=8.882 A;Z=2), a framework-type aluminosilicate with cubo-octahedral cages, have been determined by an ultrasonic method. The measured values are C_{11},88.52(71); C_{12},38.70(50); and C_{44},36.46(33) GPa. Because of its structural flexibility, the bulk modulus K_S(55.30 GPa) and shear modulus μ (31.30 GPa) values in sodalite are considerably smaller than those in densely packed cubic silicate structures such as spinel and garnet.

8080 **Dependence of optimal growth temperature on carbon content in hydrogenated amorphous silicon carbide alloys.** Winer, K. (Xerox Palo Alto Research Center, Palo Alto, California 94304 (US)). *Applied Physics Letters (USA),* 55(17): 1759-1761 (23 Oct 1989).

The temperature (T_E) above which optimal growth takes place during plasma-enhanced chemical vapor deposition of undoped hydrogenated amorphous silicon carbide alloys from methane/silane gas mixtures is shown to increase with the relative gas-phase mole fraction of methane X_{CH_4}. The increase in T_E from $\approx$220 °C for X_{CH_4}=0.0 to $\approx$350 °C for X_{CH_4}=0.90 at 2 W rf power is attributed to a corresponding decrease in the rate of hydrogen diffusion with carbon incorporation.

8081 **Fiber-optic fluorescence array to study free convection in porous media.** Perkins, R.A. (Chemical Engineering Science, Center for Chemical Technology, National Institute of Standards and Technology, 325 Broadway, Boulder, Colorado 80303 (US)); Jones, M.C. *Review of Scientific Instruments (USA),* 60(11): 3492-3497 (Nov 1989).

A 64-point fiber-optic fluorescence array is integrated into a heated-packed bed to study free convection in porous media. The array consists of 64 individual fluorescence coupler-detector modules. The array modules are designed for rhodamine 6G dye and allow real-time measurement of tracer concentrations to about 40 ppb. The coupler-detectors are inexpensive and allow a single fiber to carry both the excitation light and the emitted fluorescence light between the detectors and the remote probe terminations at known locations within the bed. Dilute pulses of tracer dye are injected into the packed bed and the dye concentration at each of the 64 fiber-optic probe terminations is monitored as a function of elapsed time. The tracer concentration as a function of time and position allows the fluid movement to be followed within the porous medium.

8082 **Thermal conductivity of dielectric thin films.** Lambropoulos, J.C. (Department of Mechanical Engineering, University of Rochester, Rochester, New York 14627 (US)); Jolly, M.R.; Amsden, C.A.; Gilman, S.E.; Sinicropi, M.J.; Diakomihalis, D.; Jacobs, S.D. *Journal of Applied Physics (USA),* 66(9): 4230-4242 (1 Nov 1989).

A direct reading thermal comparator has been used to measure the thermal conductivity of dielectric thin-film coatings. In the past, the thermal comparator has been used extensively to measure the thermal conductivity of bulk solids, liquids, and gases. The technique has been extended to thin-film materials by making experimental improvements and by the application of an analytical heat flow model. Our technique also allows an estimation of the thermal resistance of the film/substrate interface which is shown to depend on the method of film deposition. The thermal conductivity of most thin films was found to be several orders of magnitude lower than that of the material in bulk form. This difference is attributed to structural disorder of materials deposited in thin-film form. The experimentation to date has primarily centered on optical coating materials. These coatings, used to enhance the optical properties of components such as lenses and mirrors, are damaged by thermal loads applied in high-power laser applications. It has been widely postulated that there may be a correlation between the thermal conductivity and the damage threshold of these materials.

8083 **Diamond turning of L-arginine phosphate, a new organic crystal.** Fuchs, B.A. (Lawrence Livermore National Laboratory, P.O. Box 808, Livermore, California 94550 (US)); Syn, K.; Velsko, S.P. *Applied Optics (USA),* 28(20): 4465-4472 (15 Oct 1989). DOE Contract W-7405-ENG-48.

We have demonstrated that single point diamond turning can be used to generate high optical quality finished surfaces on a new organic nonlinear crystal, L-arginine phosphate (LAP). The proper choice of cutting conditions can produce surfaces with <5-A rms local roughness. Local softening or melting near the cutting tool tip may play a key role in the machining process by ensuring that material is removed by ductile cutting rather than brittle fracture. At the same time, the low melting temperature of LAP makes lubrication and cooling especially important to prevent extensive melting and tool fouling. In spite of the presence of a weak cleavage plane in LAP, the surface quality is relatively insensitive to crystallographic orientation. Tool wear is apparently negligible, so that surface flatness is governed by the stability of the diamond turning machine. These results suggest that it may be possible to fabricate large aperture LAP harmonic converters for use in inertial confinement fusion lasers.

8084 **Demonstration of completely organic, optically clear radioluminescent light.** Renschler, C.L. (Sandia National Laboratories, Albuquerque, New Mexico 87185 (US)); Clough, R.L.; Shepodd, T.J. *Journal of Applied Physics (USA),* 66(9): 4542-4544 (1 Nov 1989). DOE Contract AC04-76DP00789.

A new type of radioluminescent light source has been demonstrated. This all-organic system consists of covalently bound tritium within a solid, optically clear polymeric matrix. The matrix contains a set of organic luminophores that capture excitation energy from beta decay and red shift the energy in a stepwise fashion, after which a chosen wavelength is emitted as fluorescence. Both blue and orange lights have been fabricated. Unlike currently available tritium gas tube lights or radioluminescent paints, the brightness of these new systems is, in principle, scalable because self-attenuation and absorption effects are minimized.

8085 **Oxidation and annealing of GaAs (100) studied by photoreflectance.** Seebauer, E.G. (Laser and Atomic Physics Division, Sandia National Laboratories, Albuquerque, New Mexico 87185 (US));. *Journal of Applied Physics (USA),* 66(10): 4963-4972 (15 Nov 1989). DOE Contract AC04-76DP00789.

Photoreflectance (PR) has until now been a technique used primarily for characterization of bulk electronic band structure in semiconductors. However, since reflectance is an interfacial phenomenon, PR should in principle be sensitive to surface treatment as well. The present work appears to be the first quantitative use of PR to measure the effects of surface treatment. In particular, PR spectra of air-oxidized and of annealed GaAs(100) are shown to be substantially different from those of the clean surface. Spectra at the E_0 (1.4 eV) and E_1 (3.0 eV) transitions respond quite differently to these treatments, and the differences are explained in terms of an optical interference phenomenon due to excitons that occurs only at E_0. Effects of slow surface states have been observed with PR for the first time. The effective barrier between these states and the bulk decreases from 21±2 to 16± 2 meV upon air oxidation of the clean surface.

8086 **Proton stitching of layers of SiO_2 particles to fused silica.** Musket, R.G. (Lawrence Livermore National Laboratory, Livermore, California 94550 (US)); Thomas, I.M.;. *Journal of Applied Physics (USA),* 66(10): 5115-5118 (15 Nov 1989).

Irradiation with 100-keV protons to doses of 2.3×10^{15}–7.6×10^{16} H/cm^2 enhanced the adhesion and abrasion resistance of 220-nm-thick antireflective, optical coatings on fused silica substrates without adversely affecting the optical transmission and laser-damage threshold for 1064-nm photons. The as-deposited, sol-gel coatings consisted of porous layers of uniform, spherical silica particles having diameters of either 8 or 20 nm. The proton doses required for significant improvements in adhesion and abrasion resistance increased with particle diameter and decreased slightly for coatings precleaned by exposure to ultraviolet radiation in the presence of reactive gases.

8087 **Alternative way to locate the transition temperatures of polymeric models with loops.** Lim, H.A. (Supercomputer Computations Research Institute, Florida State University, Tallahassee, Florida 32306-4052 (US)); Burnette, D.E.;. *Physical Review [Section] A: General Physics (USA),* 40(9): 5342-5350 (1 Nov 1989).

We investigate a new criterion that can be used to locate the transition temperatures of walk models and apply the criterion to locate the transition temperatures of trails and silhouettes on a square, a triangular, a simple cubic, and a face-centered-cubic lattice. As the temperature is varied, it is observed that the odd moments or the reduced moments of the persistence lengths undergo a drastic change in a narrow temperature range. The criterion exploits this interesting observation and identifies the drastic change with a collapse of the walk configurations from the swollen phase to the compact phase. The transition temperatures obtained from this criterion for trails on the square, triangular, simple cubic, and face-centered-cubic lattice are, respectively, 1.1, 0.4, 0.6, and 0.3; and for the silhouettes they are, respectively, 1.9, 1.2, 1.4, and 0.9. The results for trails on the square and simple cubic lattices are very close to those of existing computer-simulation results of much longer chains (~250).

8088 **Ionizing-radiation effects in lanthanum magnesium aluminate crystals.** Chen, C.Y. (Solid State Division, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, Tennessee 37831-6032 (US)); Park, J.L.; Cain, L.S.; Pogatshnik, G.J.; Kokta, M.R. *Physical Review [Section] B: Condensed Matter (USA),* 40(12): 8522-8529 (15 Oct 1989). DOE Contract AC05-84OR21400.

Optical and electron-paramagnetic-resonance (EPR) techniques are used to study the effects of γ and electron irradiation on undoped lanthanum magnesium aluminate crystals. It has been shown that room-temperature irradiation produces a strong optical-absorption band at 400 nm associated with trapped-hole centers [J. Solid State Chem. 61, 67 (1986)]. The absorption band produced by the presence of this hole center is anisotropic with a preferential polarization anisotropy for $\mathbf{E}\perp c$ and the oscillator strength is found to be 0.07±0.02. The optical-absorption band can be bleached at 295 and 77 K, indicating that the excited states of the holes are close to the valence band. Polarized bleaching experiments failed to show any linear dichroism, indicating that the holes are not strongly localized at a single oxygen site. Irradiation at 77 K produces additional electron and hole centers which are presumably associated with the aluminum cations.

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8089 (INIS-mf–12023) **Materials separation and enrichment. Research and development sponsored by the Federal Minister for Research and Technology.** Kernforschungsanlage Juelich GmbH (Germany, F.R.). Projektleitung Material- und Rohstoffforschung; Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). 1987. 323p. (In German). (CONF-8711333–: Seminar on materials separation and enrichment, Goslar (Germany, F.R.), 23-24 Nov 1987). Order Number DE90732327. Available from NTIS (US Sales Only), PC A14/MF A01.

This volume supplies information in 16 individual contributions on projects sponsored by the Federal Ministry for Research and Technology (BMFT) with regard to the above mentioned topic, on the state of the art, on new technologies, and on international cooperation; two of the contributions have been recorded separately for the databases INIS and ENERGY. The contributions are supplemented by a survey of the projects sponsored and by a list of publications which have resulted from the sponsored projects. (EF).

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Refer also to citation(s) 6758, 6898, 6951, 7035, 7876, 8031, 8052, 8149, 8151, 8379, 8444, 8475, 8654, 8657, 8909

8090 (AERE-R–13137) **The differential dieaway technique applied to the measurement of the fissile content of drums of cement encapsulated waste.** Swinhoe, M.T.; Packer, T.W.;. UKAEA Harwell Lab. (UK). Nuclear Physics and Instrumentation Div.; Department of the Environment, London (UK). Mar 1988. 48p. (QCTF–87-P16;ILWRP–87-P15;DOE-RW–89.041). Available from Available from H.M Stationery Office, London, price Pound 10.00.

This report describes an investigation of a novel form of the differential dieaway technique, designed specifically for the measurement of the fissile content of 500 "litre" drums of cement encapsulated

intermediate level radioactive waste. The differences from the standard technique are that the thermalisation of the source neutrons occurs inside rather than outside the sample, and that the detectors are not symmetrically placed around the sample. The results show that the limit of detection is 10 grams of fissile material when 10^{11} source neutrons are used in the measurement. When the drum is rotated, the information from the main neutron detector results in a response which varies from 0.4 to 1.4 times the average response, depending on the position of the material in the drum. This can be improved by using the information obtained by a second detector at 90° to the first, although additional uncertainties will be introduced by the water content of the cement grout., (author).

8091 (CANMET–84-54TR) **Reverse osmosis fractionation of petroleum and synthetic crude distillates.** Farnand, B.A. (Energy, Mines and Resources Canada, Ottawa, ON (Canada)); Sawatzky, H. Canada Centre for Mineral and Energy Technology, Ottawa, ON (Canada). [1989]. 14p. (MICROLOG–89-04589). Available from PC Canada Centre for Mineral and Energy Technology, Technical Information Division, 562 Booth St., Room 20C, Ottawa, ON, CAN K1A 0G1; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

This invention is about the use of porous reverse osmosis fractionation for the upgrading of petroleum and synthetic crude distillates or for the separation of components for chemical feedstocks. As an example, the reverse osmosis separation of aromatic from non-aromatic components in naphtha and middle distillate fractions using cellulose acetate and cellulose acetate butyrate is descibed.

8092 (CIEMAT–624) **Calibration of U232 solution.** Galan, M.P.; Acena, M.L. Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas, Madrid (Spain). 1989. 19p. (In Spanish). Order Number DE89785675. Available from NTIS (US Sales Only), PC A03/MF A01.

A method for ascertaining the activity by alpha spectroscopy with semiconductor detectors, of a solution of U 232 is presented. It consists of the comparison with a U 233 solution activity previously measured in a gridded ionization chamber of 2 pi geometry. The total measurement uncertainty is about + - 0,02.

8093 (CIM/S–CE-02846, pp. 16) **Separation and characterization of surfactants present in emulsions produced in thermal recovery processes.** Mourits, F.M. (Saskatchewan Research Council, SK (Canada)); Coulombe, S. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

A study was undertaken to characterize the surfactants that stabilize emulsions occurring in enhanced recovery operations of heavy oil in Saskatchewan. Both oil-in-water emulsions, found in steamflood operations, and difficult to break water-in-oil emulsions typical of fireflood-produced crudes were included in this investigation. Fresh emulsions were collected from five thermal projects in Saskatchewan and the produced (free) water phases were subjected to ultrafiltration using membrane permeation. Following the chemical analysis of the raw permeates, three methods were used to extract and/or isolate the dissolved organic matter from the permeates: water removal by freeze-drying or rota-evaporation; extraction of the acidified permeates with ethyl acetate, followed by chromatography into acidic, neutral and basic fractions. The identification of compounds or compound classes in the isolated products was mainly based on ^{13}C nuclear magnetic resonance, gas chromatography/mass spectroscopy and infra-red analyses, but other characterization methods were also employed. The major constituents in all five sample cases were aliphatic carboxylic acids, benzoic acid and derivatives, and phenol and derivates. Differences were observed in the relative proportions of these constituents, and these differences could be related to the origin of the material. Because the isolated organic materials could not be redissolved in water, their surface activity could only be measured indirectly using the original raw permeate solutions. Interfacial tension measurements on these solutions were inconclusive. 20 refs., 3 figs., 8 tabs.

8094 (CONF-891013–9) **Dimensional analysis of continuous high-capacity electrodispersion of aqueous based liquids in an organic continuous phase.** Scott, T.C. Oak Ridge National Lab., TN (USA). [1989]. 13p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. From 6. symposium on separation science and technology for energy applications; Knoxville, TN (USA); 22-27 Oct 1989. Order Number DE90003714. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

High-intensity electric fields can be used to disperse aqueous-based solutions in a relatively nonconducting immiscible organic phase. Dimensional analysis of electrical dispersion performance from a single grounded nozzle between two charged electrodes can be characterized in terms of five dimensionless groups: an electrode height; nozzle-electrode distance; a nozzle Reynolds number; an electrical Bond number, which relates electrical to surface forces; and a Taylor number, which relates electrical to viscous forces. Experimental results on the electrodispersion of water in 2-ethyl-1-hexanol indicate that pulsed dc fields can accomplish electrodispersion utilizing a lower rms/voltage than steady dc fields. In addition, the pulsed-field behavior varies with pulse frequency with 200 Hz fields being more effective for higher continuous-phase viscosities while 2000 Hz fields are more effective when the viscosity is lower. A steady dc field displays invariant behavior with changing viscosity. In the case of the 2000 Hz field, the Taylor number remains constant for all cases tested thus indicating that the dispersion behavior is controlled by the dynamic interactions of the forces induced by the transient field with the stability of the liquid stream emanating from the nozzle. 18 refs., 8 figs.

8095 (CONF-8904296–1) **ICP/AES [Inductively Coupled Plasma/Atomic Emission Spectroscopy]: A modern analytical tool.** Sabau, C.S. Argonne National Lab., IL (USA). [1989]. 18p. Sponsored by U.S. DOE Energy Research. DOE Contract W-31109-ENG-38. From 14. annual ARA congress; Los Angeles, CA (USA); 20-22 Apr 1989. Order Number DE90003822. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A historical evolution of Inductively Coupled Plasma/Atomic Emission Spectroscopy (ICP/AES) is presented, along with the basic principles and equipment of this technique. The method of ICP/AES has developed rapidly since 1965 as an analytical tool. This modern method, which replaced combustion flames with a plasma, has proven to be superior to the traditional excitation sources in terms of precision, accuracy, and sensitivity. Several examples of analyses using this method demonstrate its advantages and multiple uses. 25 refs., 2 figs.

8096 (EUR–12240) **The certification of oxygen in copper CRM No 054R.** Vandendriessche, S. (Commission of the European Communities, Brussels (BE)); Griepink, B.; Marchandise, H.; Strijckmans, K. Commission of the European Communities, Luxembourg (Luxembourg). 1989. 23p. Available from NTIS (US Sales Only), PC A03/MF A01.

A reference material for the determination of low oxygen contents in copper (CRM 054R) has been prepared to replace the exhausted CRM 054. The homogeneity of the material is demonstrated. The oxygen content has been determined by charged particle activation analysis and confirmed by fusion extraction techniques. The mass fraction of oxygen is certified as (0.47 +- 0.04) μ g/g. 10 refs.

8097 (GSI–89-11) **Measurements of natural ^{41}Ca concentrations.** Steinhof, A. Gesellschaft fuer Schwerionenforschung m.b.H., Darmstadt (Germany, F.R.); Mainz Univ. (Germany, F.R.). May 1989. 116p. (In German). Order Number DE90728609. Available from NTIS (US Sales Only), PC A06/MF A01.

Atomic mass spectroscopic examinations on ^{41}Ca were carried out in the UNILAC accelerator. A sensitivity of about 10^{-15} was achieved. This would allow the measurement of present natural ^{41}Ca concentrations as soon as the problem of the transmission determination is solved. In this respect suggestions were worked out and their feasibility discussed. The detection of ^{41}Ca-ions is especially free of background when high UNILAC-energies are applied. An estimation showed a background level corresponding with a ^{41}Ca concentration of less then 10^{-17} referred to ^{40}Ca. Besides an independent concept for the electromagnetic concentration of ^{41}Ca with variable concentration factors was developed. After being concentrated up to 50 respectively 25 times the initial concentration in

the GSI mass separator, the ^{41}Ca concentration of three recent deer bones found in the Odenwald was measured by atomic mass spectroscopy in the 14UD-Pelletron Tandem in Rehovot (Israel). The measured ^{41}Ca concentrations ranged between 10^{-14} to 10^{-13} with consideration of the concentration factor. A theoretical study of the ^{41}Ca production in the earth's surface based on cosmic radiation illustrates the influence of trace elements on the neutron flux and thus on the ^{41}Ca production. This influence might be a possible explanation for the observed amplitude of variation of the ^{41}Ca concentration in recent bones which are of decisive importance for the feasibility of ^{41}Ca-related dating. In this work a method is suggested that does not depend on the amplitude of variation mentioned above and which would allow the determination of the erosion rate of rocks by its ^{41}Ca concentrations. (orig./HP).

8098 (INIS-BR–1761) **Rare earths determination methods, with separation pre-irradiation followed by neutron activation. Utilization of brazilian standards BB-I and GB-I.** Alcala, A.L. (Instituto de Pesquisas Energeticas e Nucleares, Sao Paulo, SP (Brazil). Div. de Radioquimica); Figueiredo, A.M.G.; Marques, L.S.; Astolfo, R. No corporate text available. 1989. 11p. (In Portuguese). (CONF-8910328–: 2. Brazilian Congress of Geochemistry, Rio de Janeiro (Brazil), 1-6 Oct 1989). Order Number DE90610739. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI.

In order to determine the rare earth elements (REE) in rocks, by neutron activation analysis, a group separation, before irradiation, was developed. The Brazilian geological standards BB-1 and GB-1, from Instituto de Geociencias da Universidade da Bahia, were analyzed. The method was based on acid digestion of the samples, cation exchange separation with a Dowex 50WX8 column and coprecipitation of the REE with calcium oxalate. Interferents like U, Th, Ta and Fe were eliminated. The concentration values of ten REE (La, Ce, Pr, Nd, Sm, Eu, Tb, Ho, Yb, and Lu) were determined. The analysis of Pr brought a contribution to the knowledge of the REE contents in these geological standards, since there are not yet results in the literature. The other REE data obtained were compared with literature values and some discrepancies are discussed. (author).

8099 (ORNL/TM–11370) **Atom probe field-ion microscopy and related topics: A bibliography, 1988.** Miller, M.K.; Hawkins, A.R. Oak Ridge National Lab., TN (USA). Oct 1989. 50p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004388. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

This bibliography includes references related to the following topics: field-ion microscopy (FIM), field emission microscopy (FEM), atom probe field-ion microscopy (APFIM), and liquid metal ion sources (LMIS). Technique-orientated studies and applications are included. The references contained in this document were compiled from a variety of sources including computer searches and personal lists of publications. To reduce the length of this document, the references have been reduced to the minimum necessary to locate the articles.

8100 (STEV-FBT–89-44) **Analysis of calcium containing phases in waste material from the ABB Carbon CTF facility.** Ljungstroem, E. (Chalmers Univ. of Tech., Goeteborg (SE). Dept. of Inorganic Chemistry); Jaeglid, U. Statens Energiverk, Stockholm (Sweden); Chalmers Univ. of Tech., Goeteborg (Sweden). Dept. of Inorganic Chemistry. 1989. 28p. Project STEV-276-363. (CTH-OOK–89-06). Order Number DE90728288. Available from NTIS (US Sales Only), PC A03/MF A01.

The X-ray method was found to be a handy tool for analysis of calcium containing phases in waste material from fluidized bed combustors. At present, some care is needed to reveal a few, faulty analyses that are produced together with the correct ones. The ashes contain no or very little lime (CaO), instead the unreacted calcium is present as limestone ($CaCO_3$). An increase in Ca/S ratio produced an increase in $CaCO_3$ and a decrease in $CaSO_4$ concentration in two cases but the opposite trend in a third case. A decrease in load produced an increase in $CaCO_3$ and a decrease in $CaSO_4$ concentration. No systematic influence from sulphur content of the coal could be observed. The large bed ash particles contain a higher $CaCO_3$ and a lower $CaSO_4$ concentration than the rest of the material for which the calcium containing phases show no systematic variation. For bed ash from an experiment where no sorbent was added, the coal ash calcium concentration was also observed in the bed ash. A considerable fraction of the calcium had reacted with the sulphur. No clue how to promote the formation of $CaMg_3(SO_4)_4$ from dolomite was found. 6 figs., 10 tabs.

8101 **Implanted standards for ion microanalysis of oxygen in beryllium.** Musket, R.G. (Lawrence Livermore National Lab., CA (USA)); Price, C.W.; Norberg, J.C. *Nuclear Instruments and Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms (Netherlands),* 42(2): 245-250 (Jun 1989). DOE Contract W-7405-ENG-48.

Implantation of 150 keV O^+ into polycrystalline beryllium internal standards for the trace analysis of oxygen in beryllium using secondary ion mass spectroscopy (SIMS). Four different oxygen fluences (1.3, 3.8, 13, and $38x10^{14}$ O/cm^2) were used to give calculated peak oxygen concentrations of 120-3700 atomic parts per million (appm) at a depth of about 310 nm. Since the measured SIMS oxygen profiles were considerably broader than that calculated by the TRIM-86 Monte-Carlo simulation program, the known integral amounts of oxygen were used to quantify the SIMS intensities. This implantation/SIMS approach permitted reliable analysis for isolated oxygen atoms in polycrystalline beryllium matrices. For the profiling conditions employed, a detection limit of about 10 appm was established. By varying the current density of the analyzing Cs^+ beam, this limit was found to be controlled by oxygen-bearing, residual gases at the surface region under analysis. (orig.).

8102 **Heavy ion backscattering spectrometry (HIBS) - an improved technique for trace element detection.** Doyle, B.L. (Sandia National Labs., Albuquerque, NM (USA)); Knapp, J.A.; Buller, D.L. *Nuclear Instruments and Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms (Netherlands),* 42(2): 295-297 (Jun 1989). DOE Contract AC04-76DP00789.

Letter-to-the-editor.

We have developed an improved approach to Rutherford backscattering spectrometry (RBS) which has hundreds of times greater sensitivity to medium-to-heavy surface impurities than conventional RBS. The basis of this technique is to use a medium-energy ($\simeq$ a few 100 keV) heavy ion beam for analysis (eg. 400 keV C^+); the key innovation is the use of a thin $\simeq$ 200 nm, self-supporting carbon foil in front of the surface-barrier detector to range out particles scattered from the substrate. Using this technique, called heavy ion backscattering spectrometry (HIBS), we have demonstrated sensitivity of better than 10^{11} at./cm^2 for Au on a Si substrate. (orig.).

8103 **Column-profile measurements using fiber-optic spectroscopy.** Kulp, T.J. (Lawrence Livermore National Lab., CA (USA)); Bishop, D.; Angel, S.M. *Soil Science Society of America Journal (USA),* 52(3): 624-627 (May-Jun 1988). DOE Contract W-7405-ENG-48. (CONF-881108–: 52. annual meeting of the Soil Science Society, Anaheim, CA (USA), 27 Nov - 2 dec 1988).

Fiber-optic spectroscopy was used to measure the flow of a fluorescent dye in a column packed with glass beads. Optical fibers inserted between the packed beads served as light pipes to transmit excitation light to the measurement zone at their distal end and to return flourescent emission to a spectrometer. In this way, the dye concentration at the point of measurement was monitored. Data are presented demonstration that flow can be monitored at several points in the column by multiplexing more than one fiber into a single spectrometer. This technique provides a tool to make fundamental flow measurement that have to date been experimentally impossible.

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Refer also to citation(s) 6499, 6544, 6585, 6593, 6625, 6938, 7035, 7056, 7102, 7179, 7180, 7944, 8017, 8022, 8145, 8445, 8585, 8593, 8672

8104 (ARC–CE-02437, pp. 55) **Some scientific considerations for catalyst preparation.** Pakash, S. (Alberta Research Council, Edmonton, AB (Canada)). Alberta Research Council, Edmonton, AB (Canada). [1982]. (CONF-8108182–: 28. congress

international union of pure applied chemistry, Vancouver (Canada), 16 Aug 1981; CE–02437). In *Alberta Research Council [research reports].* Available from CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum.

Catalyst preparation is considered to be an art; with a constant chemical composition, the catalytic characteristics may vary over a wide range, depending on the conditions and methods of preparation. The preparatory methods determine the nature of the interaction of catalyst components and, thereby, influences the dispersion, the pore structure, the crystallo-chemical characteristics and other factors which greatly influence catalytic reactions. To develop a theoretical basis for catalyst preparation, consideration should be given to the properties of a catalyst, other than its chemical composition, which influence its basic characteristics; to the identification of the optimum combination of conditions to provide a high quality catalyst for a particular reaction; and to how catalytic properties can be varied during the preparation to achieve their optimum values. A defined pore structure, the size of the internal surface and the mechanical strength of the granules are the criteria on which the success of the method would rely. These considerations are illustrated on the examples of coal liquefaction, the oxidation of isobutylene and the hydrogenolysis of ethane. 41 refs., 11 figs., 12 tabs.

8105 (BNL–43129) **The effect of electric field on attachment of electrons to solutes in liquid argon.** Holroyd, R.A. Brookhaven National Lab., Upton, NY (USA). [1989]. 6p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. Order Number DE90003969. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The use of liquid argon and xenon in detectors like time projection chambers (TPC) requires long electron drift times. This necessarily means that adventitious impurities must be reduced to very low levels. But because some impurities like oxygen may remain, it is important to understand how they affect the charge collection. In particular the effectiveness of many solutes is field dependent in liquid argon and xenon. The results of a recent study of the effect of oxygen on the attenuation length of electrons in argon are reanalyzed here to illustrate this effect. It is also shown that the addition of non-attaching solutes like methane will also change the effectiveness of impurities in capturing electrons. 8 refs., 1 tab.

8106 (BNL–43452) **Mass loss during x-ray microanalysis.** Themmer, K. (Lund Inst. of Tech. (Sweden)); Spanne, P.; Jones, K.W. Brookhaven National Lab., Upton, NY (USA). Oct 1989. 9p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-8908165–3: 5. international conference on PIXE and its analytical applications, Amsterdam (Netherlands), 20-26 Aug 1989). Order Number DE90003954. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Mass loss during photon and proton irradiation of polymer films, tissue samples and gelatin standards is studied. No difference in relative hydrogen loss is seen when varying the sample thickness. A dependence of the loss rate on the temperature in the irradiated volume is demonstrated by varying the proton irradiation parameters. The effects of the mass loss on the accuracy of the x-ray microanalysis are discussed and the absorbed doses from protons and photons to produce equivalent loss are compared. 24 refs., 8 figs., 1 tab.

8107 (DOE/ER/13954–1) **Correlations between surface structure and catalytic activity/selectivity: Progress report, September 1, 1988–September 30, 1989.** Goodman, D.W. Texas A and M Univ., College Station, TX (USA). Dept. of Chemistry. Sep 1989. 27p. Sponsored by U.S. DOE Energy Research. DOE Contract FG05-88ER13954. Order Number DE90003755. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The work now underway is directed toward the study of structural effects on catalytic activity and selectivity. For example, one of the projects outlined in the subsequent summaries addresses the effects of the presence of coordinatively unsaturated metal sites present at the reconstructed surface of platinum on the selectivity for ethane in the hydrogenolysis of butane. This work is proceeding toward the goal of generating these special sites using structural promoters on surfaces such as rhodium. Several projects are underway which are examining the novel structure and chemistry of monolayer metal films, particularly regarding their use in delineating structural effects in catalysis. One project is examining the structure and chemisorptive properties of binary overlayers of Cu and Ni on a Mo substrate.

8108 (DOE/ER/13975–1) **Frontier orbital symmetry control of intermolecular electron transfer: Progress report, September 15, 1988–October 31, 1989.** Stevens, B. University of South Florida, Tampa, FL (USA). Dept. of Chemistry. Nov 1989. 5p. Sponsored by U.S. DOE Energy Research. DOE Contract FG05-88ER13975. Order Number DE90003756. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Short communication. ORGANIC COMPOUNDS/electron transfer; PROGRESS REPORT; SPECTRA; FLUORESCENCE; ISOMERIZATION; SOLVENTS

8109 (ETDE-mf–0732408) **Ruthenium as a catalyst for simultaneous reduction of SO_2 and NO_x. Final report.** Duschner, H.; Brandt, R.; Patzelt, P. Marburg Univ. (Germany, F.R.). Fachbereich Physikalische Chemie; Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). Jan 1988. 32p. (In German). Contract BMFT 01 VQ 324. Order Number DE90732408. Available from NTIS (US Sales Only), PC A03/MF A01.

It was demonstrated that the simultaneous reduction of SO_2 and NO_x with ruthenium as a catalyst could be a possible alternative to existing methods for the reduction of sulfur dioxide and nitrous gases. A problem, however, are the high temperatures and the increased consumption of reduction agents due to the atmospheric oxygen of the flue gases. The influence of the catalyst poisons on the reactivity of the catalyst was not tested. (EF).

8110 (INIS-SU–129, pp. 234-235) **Monocrystal growth of refractory compounds of A^2B^6 type from solution-melts.** Olejnik, G.S. (AN Ukrainskoj SSR, Kiev (Ukrainian SSR). Inst. Poluprovodnikov); Trishchuk, L.I.; Mizetskij, P.A. AN SSSR, Moscow (USSR); Ministerstvo Khimicheskoj Promyshlennosti SSSR, Moscow (USSR). 1988. (In Russian). (CONF-8811251–: Symposium on molecular beam epitaxy, Moscow (USSR), 14 Nov 1988; CONF-8811252–). In *Crystal growth from solutions. Growth of monocrystals and films of high-temperature superconductors. V. 2. Extended theses.* Order Number DE90705921. Available from NTIS (US Sales Only), PC A20/MF A01 - OSTI; INIS.

Short note. 4 refs. CADMIUM CHLORIDES/phase diagrams; CADMIUM SULFIDES/crystal growth; CADMIUM SULFIDES/phase diagrams; ELECTRIC CONDUCTIVITY; INCLUSIONS; MOLTEN SALTS; MONOCRYSTALS; SOLID SOLUTIONS

8111 (UzIYaF-R–10-344) **Extraction of tungsten by tri-n-octylamine from peroxide solutions.** Brodskaya, G.A.; Gureev, E.S.; Gapurova, O.U.;. AN Uzbekskoj SSR, Tashkent (USSR). Inst. Yadernoj Fiziki. 1988. 11p. (In Russian). Order Number DE90611719. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

R-04048.

Optimal conditions of metallic tungsten dissolution in H_2O_2 were selected. Regularities of extraction of formed peroxide compounds and mono-, isopolytungstates, prepared by WO_3 or H_2WO_4 dissolution in alkali, by tri-n-octylamine (TOA) solutions, were studied. It is shown that optimal relation H_2O_2:H_2O:W during dissolution is (5-8) ml : (5-10) ml -1 g. The dependences of tungsten distribution coefficients on concentration of H_2SO_4, HCl, tungsten compounds and their forms are presented. Distribution coefficients increase with growth of TOA concentration. Composition of formed complexes was studied by IR-spectroscopy methods and according to extraction isotherms. Extraction-chromatographic method of rhenium separation from tungsten was developed. 10 refs.; 5 figs.; 1 tab.

8112 (UzIYaF-R–10-395) **Use of coextraction and suppression of extraction in extraction-chromatographic separation of elements.** Karandashev, V.K.; Kuznetsov, R.A.; Grazhulene, S.S.; Usmanova, M.M.;. AN Uzbekskoj SSR, Tashkent (USSR). Inst. Yadernoj Fiziki. 1988. 15p. (In Russian). Order Number DE90611720. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

R-04449.

TBP, solutions of hydrobromic acid, indium and polytetrafluoroethylene powder, carrier for TBP, were used to study the effects of coextraction and extraction suppression on extraction-chromatographic behaviour of microamounts of elements in the presence of macroamounts of other elements. Possibility of using these effects under extraction-chromatographic element separation were considered. A new method for extraction-chromatographic separation of scandium microamounts from the mixture of large amount of elements (Y, Cd, Ce, Eu, Lu, Hf, Ta, W, Np and other) was suggested. 15 refs.; 3 figs.

8113 Electronic states and potential energy surfaces of AgH_2: Comparison with AuH_2. Balasubramanian, K. (Arizona State Univ., Tempe (USA)); Liao, M.Z. *Journal of Physical Chemistry (USA),* 93(1): 89-94 (12 Jan 1989). DOE Contract FG02-86ER13558.

Complete active space MCSCF (CASSCF) followed by second-order configuration interaction (SOCI) and multireference single plus double configuration interaction (MRSDCI) which include excitations from the d shells are carried out on the two low-lying states of AgH_2 ($^2B_2$ and $^2A_1$). The bending potential energy curves of the two states with bond lengths optimized for all angles are presented. The $^2B_2$ surface contains a double minimum with acute and obtuse H-Ag-H angles. The $^2A_1$ surface contains a large barrier for the insertion of an $Ag(^2S)$ atom into H_2 to form the linear $^2\Sigma^+$ state of AgH_2. The excited $Ag(^2P)$ atom spontaneously inserts into H_2 to form an acute-angled weak complex of Ag with H_2 and another more stable $^2B_2$ state with obtuse bending angle. The d shell correlation lowers the $^2B_2$ obtuse-angled structure significantly. The potential energy surfaces and electronic states of AgH_2 are compared with those of AuH_2. Relativistic mass-velocity effects are significant for AuH_2 in comparison to AgH_2, while d correlation effects are more significant for AgH_2 in comparison to AuH_2. The Mulliken population analyses of the electronic states of AgH_2 reveal considerable 5p participation. The bending potential energy surfaces of the $^2B_2$ and $^2A_1$ states of both the molecules cross, which would lead to avoided crossing of the $^2E_{\frac{1}{2}}$ components if the spin-orbit term is included. The effect of f-type polarization functions is also investigated by carrying out MRSDCI calculations which included the ten-component f functions in the basis sets.

8114 An electron spin resonance investigation of the structure and formation of sulfinyl radicals: Reaction of peroxyl radicals with thiols. Swarts, S.G. (Oakland Univ., Rochester, MI (USA)); Becker, D.; DeBolt, S.; Sevilla, M.D. *Journal of Physical Chemistry (USA),* 93(1): 155-161 (12 Jan 1989).

In this work we present an electron spin resonance investigation of the irradiation of the alkyl mercaptans methyl, n-butyl, and tert-butyl mercaptan and the radioprotective thiols cysteamine and dithiothreitol in a number of aqueous and organic matrices in the present of oxygen. Matrix peroxyl radicals (ROO•) are formed after the irradiation of organic matrices in the presence of oxygen at 77 K. Upon annealing, these react with added thiols to form sulfinyl radicals (RSO•). Evidence for a thiol peroxyl radical (RSOO•) intermediate is found. Hyperfine couplings and g values are reported for the sulfinyl radicals formed from the five thiols investigated. The incorporation of ^{17}O-labeled oxygen into the RSO• radical confirms that molecular oxygen is the source of the oxygen atom in the radical. The isotropic and parallel anisotropic ^{17}O couplings indicate slightly less than 0.5 spin density on the oxygen. The couplings and spin densities are compared to those predicted from ab inito molecular orbital calculations for $CH_3SO•$. Calculations for the sulfur-peroxyl intermediate, $CH_3SOO•$, predict that it will have similar ESR parameters as those predicted for the carbon-centered peroxyl radical, $CH_3OO•$.

8115 Information theoretic prior functions for large molecular systems. Muckerman, J.T. (Brookhaven National Lab., Upton, NY (USA)). *Journal of Physical Chemistry (USA),* 93(1): 179-184 (12 Jan 1989). DOE Contract AC02-76CH00016.

Several general cases of information theoretic prior functions for large molecular systems are derived. These are intended to serve as examples for the deviation of prior functions appropriate for still other systems. General procedures are outlined for obtaining closed-form expressions for the desired prior functions in the continuous rigid-rotor, harmonic oscillator (RRHO) approximately and in the absence of angular momentum constraints, and these are applied to several cases of current experimental interest. Finally, a few cases of angular momentum deficient systems are treated.

8116 Isotropic coupling constants for the atoms B-F from correlated calculations based on spin-unrestricted wave functions. Carmichael, I. (Univ. of Notre Dame, IN (USA)). *Journal of Physical Chemistry (USA),* 93(1): 190-193 (12 Jan 1989).

Isotropic hyperfine coupling constants for the ground electronic state of the atoms B, C, N, O and F are computed by using a range of correlation procedures based on a single UHF determinant. The methods comprise (1) a variational configuration mixing approach with all configurations arising from single and double replacements in the reference wave function including an approximate size-consistency correction, (2) a many-body perturbation theory procedure based on the Moeller-Plesset expansion carried in full to fourth order and approximately extrapolated to infinite order, and (3) a coupled-cluster doubles technique partially corrected for single and triple excitations. In each case the coupling constant is derived from the normalized spin density at the nucleus, obtained by finite-field perturbation theory. Estimates of the spin density at a given nucleus from these diverse methods, using an energy-optimized and conventionally contracted, polarized basis set of approximately triple-ζ quality, are in accord with one another. Agreement is also found with the predictions of a recent MR SD-CI calculation, which employed large uncontracted basis sets, substantial reference spaces, and long configuration lists, for the comparatively electron-rich oxygen and fluorine atoms. Modest extensions to the basis set recover this accord for the theoretically more difficult cases of the electron-deficient boron and carbon atoms. Applications of these methods to the ground state of the B_2 molecule has also been pursued and provides results in reasonable agreement with experiment.

8117 Solubilities of eta-octadecane, phenanthrene, and eta-octadecane/phenanthrene mixtures in supercritical propane at 390 and 420 K and pressures to 60 bar. Dimitrelis, D. (Lawrence Berkeley Lab., CA (USA)); Prausnitz, J.M. *Journal of Chemical and Engineering Data (USA),* 34(4): 286-290 (Jul 1989). DOE Contract AC03-76SF00098.

Solubility data were obtained for n-octadecane, phenanthrene, and a nearly equimolar n-octadecane/phenanthrene mixture in supercritical propane. Solubilities were measured in a flow apparatus at 390 and 420 K over the pressure range 35-60 bar. The experimental data is correlated using the perturbed-hard-chain equation of state. Agreement between experiment and correlation is good.

8118 Reaction of $C(^3P)$ atoms with azide radicals. May, D.J. (Univ. of Denver, CO (USA)); Coombe, R.D. *Journal of Physical Chemistry (USA),* 93(2): 520-525 (26 Jan 1989).

Both continuous discharge-flow and pulsed methods have been used to investigate the reaction of carbon atoms with azide radicals. In the discharge-flow experiments, $C(^3P)$ atoms were produced by the reaction of CH_4 with excess fluorine atoms. The $C(^3P) + N_3$ reaction was found to produce CN in the $B^2\Sigma^+$ and $A^2\Pi$ excited electronic states. The rate constant of this reaction was determined from experiments in which mixtures of C_3O_2 and HN_3 were photolyzed at 193 nm. The results indicated the rate constant to have the value $(1.1 \pm 0.2) \times 10^{-10}$ cm^3 s^{-1}. This value is in accord with trends observed in other atom + N_3 reactions.

8119 Single-pulse, broad-band coherent anti-Stokes Raman spectroscopy of nitromethane within a diamond anvil cell. Rice, S.F. (Lawrence Livermore National Lab., CA (USA)); Costantino, M.S. *Journal of Physical Chemistry (USA),* 93(2): 536-538 (26 Jan 1989). DOE Contract W-7405-ENG-48.

The single-pulse, broad-band coherent anti-Stokes Raman spectrum of nitromethane in the region of the 920-cm^{-1} C-N stretching mode generated within the confines of a diamond anvil cell is reported. A signal-to-noise factor of near 50 is observed from a 3.5-μJ, 532-nm pulse combined with a 1.5-μJ, 300-cm^{-1}-wide Stokes laser pulse from a broad-band dye laser. An estimate of the anti-Stokes/Stokes conversion efficiency is calculated to be 5.5×10^{-5} and compared with an observed values of 2.1×10^{-5}, demonstrating a large enhancement over spontaneous Raman spectroscopy.

The nonresonant background from the diamonds is shown to be negligible under the focal conditions used.

8120 Rate constants for hydrogen atom attack on some chlorinated benzenes at high temperatures. Cui, J.P. (National Bureau of Standards, Gaithersburg, MD (USA)); He, Y.Z.; Tsang, W. *Journal of Physical Chemistry (USA)*, 93(2): 724-727 (26 Jan 1989).

Hydrogen atoms from the decomposition of hexamethylethane were reacted with chlorobenzene, o-dichlorobenzene, p-dichlorobenzene, and 1,2,3-trichlorobenzene in the presence of toluene or 1,3,5-trimethylbenzene in single-pulse shock tube experiments. Using the rate expression for the displacement of the methyl group from the methylated aromatics as standards the authors find $k(H + C_6H_5Cl \rightarrow C_6H_6 + Cl) = (2.2 \times 10^{10}) \exp(-4531/T)$ L/(mol × s), $k(H + o\text{-}C_6H_4Cl_2 \rightarrow C_6H_5Cl + Cl) = (9.2 \times 10^{10}) \exp(-5196/T)$ L/(mol × s), $k(H + p\text{-}C_6H_4Cl_2 \rightarrow C_6H_5Cl + Cl) = (4.6 \times 10^{10}) \exp(-4541/T)$ L/(mol × s), $k(H + 1,2,3\text{-}C_6H_3Cl_3 \rightarrow o\text{-}C_6H_4Cl + Cl) = (1.9 \times 10^{10}) \exp(-2954/T)$ L/(mol × s), and $k(H + 1,2,3\text{-}C_6H_3Cl_3 \rightarrow m\text{-}C_6H_4Cl + Cl) = (3.7 \times 10^{9}) \exp(-1856/T)$ L/(mol × s) at temperatures of 1050-1150 K and pressures between 2.5 and 3.2 atm. In this temperature range the relative rate constants on a per-chlorine basis for the five processes are 1:1.15:1.05:1.8:2.4. The absolute uncertainty in the rate expressions are of the order of 8 kJ in the activation energy and a factor of 2.5 in the A factor. The relative rate constants have an uncertainty of no more than a factor of 1.1. Rate expressions for the reverse chlorination processes have been calculated to be $k(Cl + C_6H_6 \rightarrow C_6H_5Cl + H) = (4.7 \times 10^{10}) \exp(-13453/T)$ L/(mol × s), $k(Cl + C_6H_5Cl \rightarrow o\text{-}C_6H_4Cl_2 + H) = (2.9 \times 10^{10}) \exp(-15075/T)$ L/(mol × s), and $k(Cl + C_6H_5Cl \rightarrow p\text{-}C_6H_4Cl_2 + H) = (6.8 \times 10^{9}) \exp(-13614/T)$ L/mol × s.

8121 Influence of swelling on reaction efficiency in intercalated clay minerals. 2. Pillared clays. Politowicz, P.A. (Australian National Univ., Canberra); San Leung, L.B.; Kozak, J.J. *Journal of Physical Chemistry (USA)*, 93(2): 923-926 (26 Jan 1989).

Methods for intercalating thermally stable, polynuclear hydroxy metal cations and/or metal cluster cations in smectite clays have been developed in recent years as a means of keeping separate the silicate layers in the absence of a swelling solvent. Since the pillaring cations are space filling, the interlamellar reaction space will be broken up into an interconnected set of channels through which a diffusing species can migrate. In this paper, a lattice model is designed to determine how different spatial distributions of pillaring agents and different interlamellar spacings can influence the efficiency of reaction between a fixed target molecule and a diffusing coreactant. The authors study two regular distributions of pillaring cations and calculate the mean reaction time (as calibrated by the mean walklength $\langle n \rangle$) of the diffusing coreactant as a function of the separation between silicate layers. All other factors being held constant, they find a significant increase in the reaction efficiency with increase in the number of channels available to the coreactant. They also find that for each distribution there is a decrease in reaction efficiency as one increases the interlayer spacing, with the surprising result that for large arrays the addition of one or two layers above the basal plane (where the target molecule is anchored at the centrosymmetric site) leads to essentially the same relative changes in the reaction efficiency regardless of the spatial distribution considered.

8122 Structural basis of the impact sensitivities of 1-picryl-1,2,3-triazole, 2-picryl-1,2,3-triazole, 4-nitro-1-picryl-1,2,3-triazole, and 4-nitro-2-picryl-1,2,3-triazole. Storm, C.B. (Los Alamos National Lab., NM (USA)); Ryan, R.R.; Ritchie, J.P.; Hall, J.H.; Bachrach, S.M. *Journal of Physical Chemistry (USA)*, 93(2): 1000-1007 (26 Jan 1989).

The isomeric pairs 1-picryl-1,2,3-triazole, 2-picryl-1,2,3-triazole and 4-nitro-1-picryl-1,2,3-triazole, 4-nitro-1-picryl-1,2,3-triazole differ dramatically in their impact sensitivity. Since these pairs of compounds have identical oxygen balance this strongly suggests that there is a difference in the decomposition mechanism. The authors report here the x-ray crystal structure, molecular orbital calculations, and ^{13}C and ^{1}H NMR spectra of the four compounds. The picryl substituents are essentially identical in all four cases. The most significant structural difference in the X-ray structures and in the molecular orbital calculations is a decrease in the N2-N3 bond length, accompanied by a lengthening of the adjacent bonds, in the two 1-picryl isomers relative to the corresponding bond lengths in the 2-picryl isomers. Molecular orbital calculations show that this leads to a low activation energy for the elimination of N_2 from the 1-picryl isomers. They suggest that this initial step then leads to a reactive intermediate and is responsible for the large difference in sensitivity.

8123 A new determination of the dissociation energy of acetylene. Green, P.G. (Department of Chemistry and George R. Harrison Spectroscopy Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139 (US)); Kinsey, J.L.; Field, R.W. *Journal of Chemical Physics (USA)*, 91(9): 5160-5163 (1 Nov 1989).

A new *upper bound* for the dissociation energy of acetylene, D^0_0(HCC–H) =529.89(±0.01) kJ/mol, has been determined by Stark anticrossing spectroscopy. The zero-pressure extrapolated (unimolecular) decay rates of levels of S_1 ($\tilde{A}\ ^1A_u$) v'_3=2 and 3 (quanta of the *trans*-bending vibration) *increase* upon application of an electric field of 113 kV/cm. We attribute this increase in molecular decay rate to *predissociation* rather than any other Stark-induced nonradiative or radiative phenomenon. The lowest level (v'_3 =2, J'=2, K'=1) from which we have observed an increase in decay rate (i.e., predissociation) has an internal energy of 44 295.65 cm^{-1} relative to v=0, J=0 of S_0 ($\tilde{X}\ ^1\Sigma^+_g$). This corresponds to a value about 24 kJ/mol lower then the consensus *upper bound* result from four different recent experimental determinations (including one of ours) as well as current *ab nitio* results. The new value agrees, however, with earlier work and with recent modeling studies of acetylene pyrolysis kinetics.

8124 Rotational populations in OD formed in the reaction $O(^1D)+D_2$ investigated by infrared rotational absorption spectroscopy. Sears, T.J. (Department of Chemistry, Brookhaven National Laboratory, Upton, New York 11973 (US)); Hall, G.E.; McAndrew, J.J.F. *Journal of Chemical Physics (USA)*, 91(9): 5201-5207 (1 Nov 1989). DOE Contract AC02-76CH00016.

Diode laser transient absorption/gain spectroscopy is used to monitor time-dependent populations of high rotational levels in OD (v=0) produced in the reaction of $O(^1D)+D_2$. Pure rotational transitions on species with large dipole moments offer good sensitivity, full state resolution and μs time resolution in the present apparatus. Measured nascent populations of OD in the four highest rotational levels thermodynamically accessible in this reaction are in reasonable agreement with the reported results of earlier laser-induced-fluorescence measurements, in which corrections for transition moments and predissociation introduce increasing uncertainties at high rotational levels. The relaxation kinetics of the highest rotational levels are not hopelessly complex, and evidence is presented for strong, but not complete propensity for conservation of Λ doublet symmetry during rotational relaxation.

8125 Normal-mode analysis of liquid-state dynamics. Seeley, G. (Department of Chemistry, Boston University, Boston, Massachusetts 02215 (US)); Keyes, T. *Journal of Chemical Physics (USA)*, 91(9): 5581-5586 (1 Nov 1989).

Harmonic normal-mode analysis is applied to Lennard-Jones (LJ) liquids. The configuration-averaged density of (vibrational) states is obtained via numerical eigenanalysis of the force-constant matrices appropriate to an ensemble of liquid configurations; the configurations are generated by computer simulation. The contribution of unstable modes is included and plays a crucial role in the analysis. It is argued that the density of states contains information which may be used to construct theories of liquid-state dynamics. The argument is pursued at two levels. First, it is demonstrated that a glance at the density of states conveys a powerful, intuitive understanding of several aspects of the dynamics. Second, a theory of the self-diffusion constant is constructed which may be regarded as a preliminary attempt to base systematic transport theory upon normal-mode quantities.

8126 Layer resolved spectroscopy of potassium adsorbed on a Ru(001) surface: Photoemission and thermal desorption study. Hrbek, J. (Chemistry Department, Brookhaven National Laboratory, Upton, New York 11973 (US)); Shek, M.; Sham, T.K.; Xu,

G. *Journal of Chemical Physics (USA)*, 91(9): 5786-5792 (1 Nov 1989). DOE Contract AC02-76CH00016.

High-resolution photoemission spectroscopy and thermal desorption were used to study the coverage dependence of the K $3p_{3/2,1/2}$ core levels of K overlayers on Ru(001). Three doublets were observed to evolve sequentially and to shift to higher binding energy with increasing coverage of potassium. The doublets were assigned to photoemission from the interface (first layer), "bulk" (second layer), and surface (third layer). Spin–orbit splitting was observed for the first time in the condensed potassium phase by photoemission. The results are discussed in terms of the equivalent core approximation using a Born–Haber cycle. In the thermal desorption data three coverage regimes can be distinguished: a first layer desorbing with first-order kinetics and a strongly decreasing heat of adsorption (E_A =2.80–0.87 eV); a second layer with zero-order desorption kinetics and E_A =0.78 eV; a third layer and multilayers with the same kinetic order but with E_A increasing from 0.78 to 0.93 eV, which is close to the heat of sublimation of potassium.

8127 **Microscopic theory of the dynamics of polymeric liquids: General formulation of a mode–mode-coupling approach.** Schweizer, K.S. (Sandia National Laboratories, Albuquerque, New Mexico 87185 (US)). *Journal of Chemical Physics (USA)*, 91(9): 5802-5821 (1 Nov 1989). DOE Contract AC04-76DP00789.

A formally exact, nonlinear generalized Langevin equation (GLE) for a flexible probe polymer in a dense melt has been derived using molecular phase space kinetic theory and Mori–Zwanzig projection operator techniques. An approximate, linearized dynamic memory function is developed, and the resulting GLE is specialized to the problem of an overdamped liquid of uncrossable Rouse polymers. An analytically tractable, perturbative/short time evaluation of the projected force time correlation function matrix is proposed which accounts for uncorrelated intermolecular pair interaction effects in the polymer melt. The detailed predictions for transport coefficients and various time correlation functions are determined for linear chains, and compared with recent lattice Monte Carlo simulations. Significant slowing down of all dynamical processes relative to the Rouse behavior is found, but the molecular weight scaling is not correctly described. A nonperturbative approach based on a polymeric generalization of molecular-scale mode–mode coupling theory is formulated which does properly capture the strong caging and viscoelastic effects in dense melts.

8128 **Mode-coupling theory of the dynamics of polymer liquids: Qualitative predictions for flexible chain and ring melts.** Schweizer, K.S. (Sandia National Laboratories, Albuquerque, New Mexico 87185 (US)). *Journal of Chemical Physics (USA)*, 91(9): 5822-5839 (1 Nov 1989). DOE Contract AC04-76DP00789.

The qualitative predictions of the mode–mode-coupling (MMC) theory developed in the preceding paper are determined for various transport properties and time correlation functions. The degree of polymerization N dependence of the self-diffusion constant D of long flexible chain and rigid rod melts are found to be in agreement with the reptation/tube model scaling predictions. Ideal ring polymer liquids also follow a $D \propto N^{-2}$ law, but for collapsed non-Gaussian rings a stronger power law dependence is obtained. The viscoelastic properties of chain melts are derived from a linear generalized Langevin equation (GLE), which at long times consists of the usual Rouse terms plus a chain length and internal normal mode-dependent frictional contribution.

8129 **State-selective ionization of nitrogen in the $X\,^2\Sigma^+{}_g v_+=0$ and $v_+=1$ states by two-color (1+ 1) photon excitation near threshold.** Trickl, T. (Materials and Chemical Sciences Division, Lawrence Berkeley Laboratory and Department of Chemistry, University of California, Berkeley, California 94720 (US)); Cromwell, E.F.; Lee, Y.T.; Kung, A.H.;. *Journal of Chemical Physics (USA)*, 91(10): 6006-6012 (15 Nov 1989). DOE Contract AC03-76SF00098.

Efficient generation of $N^+{}_2X\,^2\Sigma^+{}_g(v_+=0,1)$ is demonstrated by an extreme-ultraviolet +visible (1+1) photon excitation scheme. The $c'_4\,^1\Sigma^+{}_u$ ($v'=0,1$) Rydberg states are used as intermediates. The N_2 molecules are ionized near the $v_+=0$ and $v_+=1$ ionization thresholds. The autoionizing $nd\delta_g\,^1\Delta_g$ Rydberg series with the rotational quantum numbers N=4, 5, and 6 (in the limit of l uncoupling) are observed for the first time. Extrapolation of the N=4 series yields an ionization energy of N_2 of 125 666.959(67) cm^{-1}.

8130 **Potential energy surfaces for $NbH^+{}_2$ and $MoH^+{}_2$.** Das, K.K. (Department of Chemistry, Arizona State University, Tempe, Arizona 85287-1604 (US)); Balasubramanian, K.;. *Journal of Chemical Physics (USA)*, 91(10): 6254-6267 (15 Nov 1989).

Electronic structures, potential energy surfaces (PES), and some one-electron properties of 12 electronic states of the $NbH^+{}_2$ and $MoH^+{}_2$ ions are studied using the complete active space MCSCF (CASSCF) followed by multireference singles plus doubles configuration interaction (MRSDCI) calculations. The $^3B_2$ ground state of $NbH^+{}_2$ (r_e =1.687 A, θ_e =105.2°) is formed by the spontaneous insertion of $Nb^+(a^3F, 4d^85s^1)$ into H_2 while the lowest $a\,^5F(4d^85s^1)$ state of the Nb^+ ion has to surmount a barrier to 56 kcal/mol to insert into H_2. The ground state ($^4B_2$) potential energy curve of $MoH^+{}_2$ contains two minima with geometries: r_e =1.637 A, θ_e =37° and r_e =1.626 A, θ_e =115.7°. The a^4G state of Mo^+ inserts spontaneously into H_2 to form the $^4B_2$ state of $MoH^+{}_2$, while the ground state ($a\,^6S$, $4d^5$) of the Mo^+ ion has to overcome a barrier of 74 kcal/mol to form the linear $^6\Pi_u$ state of the $MoH^+{}_2$ ion. In the collinear mode of interaction, the ground state of Mo^+ forms a van der Waals complex which is only 1.2 kcal/mol more stable than $Mo^+{+}H_2$. In general, all the low-lying states of $NbH^+{}_2$ and $MoH^+{}_2$ are formed from the excited low-spin states of the metal ions. The PES of $NbH^+{}_2$ were found to be similar to the neutral surfaces confirming Smalley and coworkers experimental findings. The addition of f-type diffuse functions does not alter the geometries much.

8131 **State-resolved evidence for hot carrier driven surface reactions: Laser-induced desorption of NO from Pt(111).** Buntin, S.A. (Center for Atomic, Molecular and Optical Physics, National Institute of Standards and Technology, Gaithersburg, Maryland 20899 (US)); Richter, L.J.; King, D.S.; Cavanagh, R.R.;. *Journal of Chemical Physics (USA)*, 91(10): 6429-6446 (15 Nov 1989).

State-specific diagnostics are used to characterize the laser-induced desorption of NO from Pt(111). Two desorption channels are observed; one is consistent with thermal activation, while the other is driven by adsorbate interactions with hot carriers. For this latter channel, the observed dependence of the desorption yield on the wavelength of the incident laser pulse (1907, 1064, 532, and 355 nm) and the wavelength dependence of the kinetic energy distributions establish the nonthermal nature of the excitation process. The inverted spin–orbit population, the non-Boltzmann rotational state distributions, and the vibrational state population are interpreted in terms of a desorption mechanism involving a temporary ion resonance.

8132 **Symmetry breaking in a chemical pinwheel.** Kreisberg, N. (Center for Nonlinear Dynamics and the Department of Physics, The University of Texas, Austin, Texas 78712 (US)); McCormick, W.D.; Swinney, H.L.;. *Journal of Chemical Physics (USA)*, 91(10): 6532-6533 (15 Nov 1989).

A transition that breaks the m-fold rotational symmetry of a chemical pattern of traveling waves is reported. The chemical waves travel around a thin annular gel, the inner and outer edges of which are in contact with continuous flow chemical reservoirs. Observations of the dependence of the rotating wave pattern as a function of temperature reveal several distinct states, including a wavelength-doubled state in which successive waves alternate in shape.

4004 Electrochemistry

Refer also to citation(s) 7869, 8066

8133 (DOE/ER/13506–26) **Bilayer lipid membrane-supported electronic devices.** Fendler, J.H. Syracuse Univ., NY (USA). Dept. of Chemistry. [1989]. 3p. Sponsored by U.S. DOE Energy Research. DOE Contract FG02-86ER13506. (CONF-8911142–1: International symposium on self-assembly of organic compounds, Fukuoka (Japan), 6-9 Nov 1989). Order Number DE90003449. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Short communication. SEMICONDUCTOR DEVICES/ electrochemistry; ELECTROCHEMISTRY; LAYERS; LIPIDS

4005 Photochemistry

Refer also to citation(s) 8074, 8117, 8118

8134 (LA-UR-86-2600, pp. 48-65) **Photoconductivity and picosecond signals.** Hammond, R.B. Los Alamos National Lab., NM (USA). Fal 1986. In *Los Alamos science, Number 14.* Order Number DE87003612. Available from NTIS, PC A06/MF A01.

Photoconductivity is by no means an unheard-of phenomenon, having been used for decades as a mechanism for converting light to electrical signals and as a tool for studying the physics of solids. But two recently discovered features of photoconductivity-an extraordinarily rapid onset and, in some materials, a similarly rapid decay-have made it the basis for new class of electronic devices with exciting applications in diverse areas of research and technology. The Electronics Division at Los Alamos is a leader in developing the new photoconductive devices. Switches for initiating near billion-watt pulses of electric power in less than a nanosecond (10^{-9} second), detectors for tracking the rapidly varying radiation from fission and fusion reaction, and instruments for studying the behavior of integrated-circuit components during intervals as short as a picosecond (10^{-12} second) have been demonstrated.

8135 **Resonant two-photon ionization spectroscopy of jet-cooled p-dichlorobenzene.** Rohlfing, E.A. (Sandia National Labs., Livermore, CA (USA)); Rohlfing, C.M. *Journal of Physical Chemistry (USA),* 93(1): 94-101 (12 Jan 1989).

This paper reports resonant two-photon ionization (R2PI) with reflectron time-of-flight mass spectrometry on jet-cooled p-dichlorobenzene (p-DCB) performed to study both the mechanism of multiphoton ionization/dissociation (MPID) at high laser intensities and the $^1B_{2u}$-^1A_g excitation spectrum at low laser intensities. Ionization via the 5^1_0 band at 274.10 nm under MPID conditions produces almost no $C_6H_4Cl^+$. This observation demonstrates that dissociation of the parent ion at the three-photon level is too slow to compete with the higher energy processes that produce small fragments via additional photon absorption. However, absorption of one visible photon (548.20 nm) from the three-UV-photon level dramatically increases the rate of dissociation of the parent ion to form $C_6H_4Cl^+$. A comparison of one- and two-color R2PI spectra (where the second color is 266 nm) allows us to bracket the adiabatic ionization potential (IP) for p-DCB as $8.90 \text{ eV} \leq IP \leq 8.95 \text{ eV}$, in good agreement with previous measurements. High mass selectivity enables us to measure chlorine isotope shifts for 26 vibrational bands in the first 1100 cm^{-1} of the $^1B_{2u}$-^1A_g R2PI spectrum. All-electron ab initio molecular orbital calculations are performed on the ground state of p-DCB to determine theoretical chlorine isotope shifts that, after appropriate scaling to the excited state, are compared to the observed isotope shifts. This procedure allows a straightforward assignment of almost all of the observed vibrational bands and gives vibrational frequencies for 11 modes in the excited state.

8136 **A flash photolysis-shock tube kinetic study of the H atom reaction with O_2: $H + O_2 \rightleftharpoons OH + O$ ($962 \text{ K} \leq T \leq 1705 \text{ K}$) and $H + O_2 + Ar \rightarrow HO_2 + Ar$ ($746 \text{ K} \leq T \leq 987 \text{ K}$).** Pirraglia, A.N. (Brookhaven National Lab., Upton, NY (USA)); Michael, J.V.; Sutherland, J.W.; Klemm, R.B. *Journal of Physical Chemistry (USA),* 93(1): 282-291 (12 Jan 1989). DOE Contract AC02-76CH00016.

Rate constants for the reactions $H + O_2 \rightarrow OH + O$ (1) and $H + O_2 + M \rightarrow HO_2 + M$ (2) were measured under pseudo-first-order conditions by the flash photolysis-shock tube technique that employs the atomic resonance absorption detection method to monitor $[H]_t$. Rate data for reaction 1 were obtained over the temperature range from 962 to 1705 K, and the results are well represented by the Arrhenius expression $k_1(T) = (2.79 \pm 0.32) \times 10^{-10} \exp(-16132 \pm 276 \text{ cal mol}^{-1}/RT) \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$. The mean deviation of the experimentally measured rate constants from those calculated by using this expression is ±16% over the stated temperature range. The recent shock tube data of Frank and Just (1693-2577 K) were combined with the present results for $k_1(T)$ to obtain the following Arrhenius expression for the overall temperature span (962-2577 K); $k_1(T) = (3.18 \pm 0.24) \times 10^{-10} \exp(-16439 \pm 186 \text{ cal mol}^{-1}/RT) \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$. The mean deviation of the experimentally measured rate constants from this expression is ±15% over the entire temperature range. Values for the rate constant for the reverse of reaction 1 were calculated from each of the experimentally measured $K_1(T)$ values with expressions for the equilibrium constant derived by using the latest JANAF thermochemical data. These $k_{-1}(T)$ values were also combined with similarly derived values from the Frank and Just data.

8137 **Photoeffects in thin-film molecular-level chromophore-quencher assemblies. 1. Physical characterization.** Surridge, N.A. (Univ. of North Carolina, Chapel Hill (USA)); McClanahan, S.F.; Hupp, J.T.; Danielson, E.; Gould, S.; Meyer, T.J. *Journal of Physical Chemistry (USA),* 93(1): 294-304 (12 Jan 1989). DOE Contract AS05-78ER06034.

Molecular-level chromophore-quencher assemblies have been prepared in precast chlorosulfonated polystyrene ($[-CH_2CH(p\text{-}C_6H_4SO_2Cl)]_x$-; PS-$SO_2Cl$) films by (1) exposing the intact film to solutions containing the chromophore $[(bpy)_2Ru(5\text{-}NH_2phen)][PF_6]_2$ (bpy is 2,2'-bipyridine; 5-NH_2phen is 5-amino-1,10-phenanthroline) which becomes chemically bond through sulfonamide bond formation, (2) partially hydrolyzing a portion of the remaining -SO_2Cl sites to -SO_3- sites and exposing the resulting films to acetonitrile solutions containing the electron-transfer quencher paraquat (PQ^{2+}) and the reductive scavenger triethanolamine ($N(C_2H_4OH)_3$). The photophysical properties of the chromophore-based metal-to-ligand charge-transfer excited state have been investigated by lifetime and visible absorption and emission spectra. Although similar to related monomers, excited-state decay in the films is nonexponential. The dynamics of excited-state quenching by PQ^{2+} following pulsed laser excitation show that the chromophore occupies three different chemical sites within the films. At one site, which accounts for ≈50% of the emitted light and appears to be located near ion channels created by hydrolysis, quenching is rapid, $K_{SV} \approx 6.8 \times 10^4$ M^{-1}. A second site exists that undergoes relatively slow quenching, $K_{SV} \approx 3 \times 10^3$ M^{-1}, and then only with added $[NEt_4](ClO_4)$. A third site is present that is not quenched.

8138 **Photoeffects in thin-film molecular-level chromophore-quencher assemblies. 2. Photoelectrochemistry.** Surridge, N.A. (Univ. of North Carolina, Chapel Hill (USA)); Hupp, J.T.; McClanahan, S.F.; Gould, S.; Meyer, T.J. *Journal of Physical Chemistry (USA),* 93(1): 304-313 (12 Jan 1989). DOE Contract FG05-86ER13633.

Photocurrents appear upon visible photolysis of thin films of chlorosulfonated polystyrene ($[-CH_2CH(p\text{-}C_6H_4SO_2Cl)]_x$-; PS-$SO_2Cl$) containing the chemically attached chromophore $[(bpy)_2Ru(5\text{-}NH_2phen)](PF_6)_2$ (bpy is 2,2'-bipyridine, 5-NH_2phen is 5-amino-1,10-phenanthroline). The chemical attachment is by sulfonamide binding. The photocurrents arise following oxidative quenching of the metal-to-ligand charge-transfer excited state(s) of the complex by paraquat (PQ^{2+}) in the presence of the reductive scavenger TEOA, triethanolamine. A kinetic model has been derived that accounts for variations in photocurrent with light intensity and $[PQ^{2+}]$ or [TEOA] in the external solution. Comparisons with earlier quenching studies obtained by laser flash photolysis show that only a fraction of the chromophores in the film contribute to the photocurrent. The efficiency of photocurrent production depends upon the concentration gradient of the chromophore. It rises initially as the chromophore content increases but falls dramatically in films where the chromophore has reached the electrode-film interface. Under maximal conditions the per photon absorbed quantum yield for photocurrent production reached the electrode-film interface. Under maximal conditions the per photon absorbed quantum yield for photocurrent production reached 0.14, 0.18 with 0.1 M isopropyl alcohol added.

8139 **An electron spin resonance study of charge separation in frozen sodium dodecyl sulfate micellar solutions containing tris(2,2'-bipyridine)ruthenium(II) complexes and alkylmethylviologens.** Colaneri, M.J. (Univ. of Houston, TX (USA)); Kevan, L.; Schmehl, R. *Journal of Physical Chemistry (USA),* 93(1): 397-401 (12 Jan 1989).

Photoexcitation of tris(bipyridine)ruthenium bound to sodium dodecyl sulfate micelles containing methylviologen at 77 K results in net electron transfers to produce the methylviologen cation radical, which is observed by electron spin resonance. The efficiency of this process has been studied as a function of the addition of alkyl chains to both the viologen and the ruthenium complex. An optimal yield is found for alkyl (C_5 to C_{17}) ruthenium complexes with

hexylmethyl- and octylmethylviologen. These results are explained in terms of embedment into the micelle interface to varying degrees depending on alkyl chain length. A high radical yield is also found with the alkylruthenium complex and longer alkyl chain alkylmethylviologens in frozen aqueous solutions without micelles. Here, the radical yields are explained in terms of alkylmethylviologen aggregation and interaction with alkylruthenium complexes. In the presence of sodium dodecyl sulfate micelles the aggregation is prevented, and the radical yields change accordingly. It is generally concluded that alkyl chains on the electron donor and acceptor generate subtle ultrastructural changes that potentially allow control of the photoinduced electron-transfer efficiency.

8140 Photochemistry of O_3/HN_3 mixtures. Ongstad, A.P. (Univ. of Denver, CO (USA)); Coombe, R.D.; Neumann, D.K.; Stech, D.J. *Journal of Physical Chemistry (USA),* 93(2): 549-552 (26 Jan 1989).

Gaseous mixtures of HN_3 and O_3 were photolyzed with the 249-nm output of a pulsed KrF laser. The photolysis produces $O(^1D)$ atoms, which react with HN_3 to produce N_3 radicals and with the N_3 radicals to produce electronically excited $NO(A^2\Sigma^+)$. Rate constants for these reactions were determined from comparison of the experimental NO A $\rightarrow$ X emission time profiles with $NO(A^2\Sigma^+)$ densities calculated from a kinetic model for the system. The rate constants for $O(^1D) + HN_3$ and $O(^1D) + N_3$ were determined to be $(3.2 \pm 1.0) \times 10^{-10}$ cm^3 s^{-1} and $(1.0 \pm 0.3) \times 10^{-10}$ cm^3 s^{-1}, respectively.

8141 Matrix photochemistry of hypofluorous acid, HOF: Oxygen atom transfer and other reactions. Appleman, E.H. (Argonne National Lab., IL (USA)); Downs, A.J.; Gardner, C.J. *Journal of Physical Chemistry (USA),* 93(2): 598-608 (26 Jan 1989).

The infrared spectrum of the hypofluorous acid molecule, HOF, trapped in different solid matrices at low temperatures shows that the vibrational fundamentals ν_1 and ν_2 are perturbed to extents that vary with the basicity of the adjacent molecule, D, and the appearance of absorptions attributable to librational motions of the D···H-OF unit implies the formation of specific hydrogen-bonded complexes in some cases. As the matrix concentration of HOF increases, aggregation occurs to give $(HOF)_2$ and higher multimers. Exposure of HOF isolated in an Ar matrix to broad-band ultraviolet radiation results in photodissociation with the formation of two products thought to be O···$(HF)_2$ and O_2···$(HF)_2$ in proportions dependent on the concentration of HOF. Photolysis of HOF trapped in a reactive matrix results in oxygenation of the matrix molecules, X, and complexation of the product XO by HF; e.g. X = N_2, CO, O_2, or CH_4. The CO, O_2, or CH_4 matrices also yield on photolysis small but significant amounts of $FCO^•$, $O_2F^•$, or CH_3···HF, respectively, products that signal the intervention of fluorine atoms. Photolysis of an Ar matrix including HOF together with a potential substrate, Y, at concentrations > 1% results exclusively in oxygenation, and not fluorination, to give YO (Y = PF_3, AsF_3, or H_2O). The results are discussed in relation to the mechanisms likely to govern the matrix photochemistry of HOF.

8142 Evaluation of approximations in molecular exciton theory. 2. Applications to oligomeric systems of interest in photosynthesis. LaLonde, D.E. (Univ. of Kansas, Lawrence (USA)); Petke, J.D.; Maggiora, G.M. *Journal of Physical Chemistry (USA),* 93(2): 608-614 (26 Jan 1989).

Molecular exciton calculations have been performed on bacteriochlorin and methyl bacteriopheophorbide a (Me-BPheo-a) oligomers in one-dimensional stacked geometries, in an investigation of spectral shifts and oscillator strengths of the X_y band. Exciton matrix elements were evaluated by using both the point dipole and Shipman distributed point-charge approximations of monomeric electron densities, obtained from floating-Gaussian-based SCF-MO-CI monomer wave functions. Calculations performed with the point-dipole approximation produced unacceptable errors in both Q_y spectral shifts and oscillator strengths, relative to those obtained with the more rigorous point-charge approximation. For both approximations, calculations in which only nearest-neighbor intermolecular interactions were considered significantly underestimated the spectral shifts obtained with the inclusion of all interactions. However, neglect of interactions between molecules separated by >20 Å did not significantly affect the values of calculated spectral shifts. The present point-charge-based calculations on Me-BPheo-a oligomers indicate that the method appears to account for approximately 50-60% of the Q_y red shift observed in crystals. Thus, additional factors such as the use of higher quality monomeric wave functions in the exciton treatment, as well as consideration of charge-transfer and charge redistribution effects, appear necessary to obtain accurate spectral shifts.

8143 Photoelectrochemistry in particulate systems. 9. Photosensitized reduction in a colloidal TiO_2 system using anthracene-9-carboxylic acid as the sensitizer. Kamat, P.V. (Univ. of Notre Dame, IN (USA)). *Journal of Physical Chemistry (USA),* 93(2): 859-864 (26 Jan 1989).

Time-resolved laser flash photolysis and fluorescence quenching studies have been carried out to elucidate the processes of charge injection from the excited anthracene-9-carboxylic acid (9AC) into the conduction band of TiO_2 semiconductor colloid and the reaction of sensitized TiO_2 colloid with an electron acceptor. 9AC adsorbed strongly on colloidal TiO_2 with an apparent association constant of 6450 M^{-1}, and its fluorescence emission was quenched by TiO_2 colloid with an efficiency of 94%. Only the singlet excited state of 9AC was found to participate din the sensitization of TiO_2 with a rate constant of 4.8×10^8 s^{-1} for the process of charge injection into the conduction band of the semiconductor. Analysis of the transient absorption spectra confirmed the generation of cation radical ($9AC^{+•}$), most of which decayed quickly by recombining with the injected charge. The rate constant for the back electron transfer was found to be 5.5×10^7 s^{-1}. The small fraction of the injected charge (~ 10%) that survived within the particle was used to reduce another substrate, N,N,N',N'-tetraethyloxonine. the quantum yield for such a sensitized reduction process was 0.015. The role of the sensitizer and the semiconductor in promoting the sensitized reduction process is described.

8144 Vesicle surface charge effects on the photoionization of zinc tetraphenylporphyrin studied by electron spin resonance. Lanot, M. (Univ. of Houston, TX (USA)); Kevan, L. *Journal of Physical Chemistry (USA),* 93(2): 998-1000 (26 Jan 1989).

The photoionization of zinc tetraphenylporphyrin in rapidly frozen neutral dipalmitoylphosphatidylcholine vesicles has been compared with that in mixed negatively charged vesicles formed by adding dihexadecyl phosphate and in mixed positively charged vesicles formed by adding dioctadecyldimethylammonium chloride. The radical cation yield decreases in negatively charged vesicles and increases in positively charged vesicles, demonstrating a surface charge effect. The results can be explained by a simple electrostatic model that is also applicable to micellar systems.

4006 Radiation Chemistry

Refer also to citation(s) 7557, 7558, 7559, 8113

8145 (AECS-FRSR–26) Mechanism of thermal decomposition of irradiated and unirradiated KIO_4 and X.R.D spectroscopy. Takriti, Salaheddin (Atomic Energy Commission, Damascus (Syria));. Atomic Energy Commission, Damascus (Syria). Dec 1988. 25p. (In Arabic). Order Number DE90611807. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The thermal decomposition of gamma-ray irradiated KIO_4 hase been studied. The decomposition isotherms present a saturation value at long heating times. Also a saturation value has been observed for the decomposition fraction as a function of the absorbed gamma-ray dose. Kinetic analysis of the irradiated decomposition data shows a decrease in the dimensionality of the reaction ,n, from the Erofeev equation, compared with the unirradiated KIO_4, (n is constant and equal 1.8 for the irradiated and varies between 2-3 for the unirradiated, the activation energy is about 1 eV). The effect of gamma-ray was investigated and it was shown that all the isotherms reach the same value with diffrent gamma-ray doses. X-ray diffraction of the KIO_4 after taking off the outer part of crystal has been studied to determine the crystalography variation due to heating and irradiation. The analysis of this data shows a decrease of the surface area corresponsing to (hk1) plane as a function of the decomposition degree and gamma-ray dose. This means that there is a variation of the concentration of atoms in (hk1) plane. The

positron annihilation has been studied in order to obtain more informations about the defects, but the variation of its intensity is very small. 32 refs., 7 figs. (author).

8146 **Dynamics of excess electron migration, solvation, and spectra in polar molecular clusters.** Barnett, R.N. (School of Physics, Georgia Institute of Technology, Atlanta, Georgia 30332 (US)); Landman, U.; Nitzan, A. *Journal of Chemical Physics (USA)*, 91(9): 5567-5580 (1 Nov 1989).

The dynamics of excess electron localization, migration, and solvation in water and ammonia clusters, and the time-resolved spectroscopic consequences of these processes, are investigated via computer simulations. In these simulations, the solvent evolves classically and the electron propagates in the ground state. The coupling between the polar molecular cluster and the electron is evaluated via the quantum expectation value of the electron–molecule interaction potential. Starting from an electron attached to a cold molecular cluster in a diffuse weakly bound surface state, temporal stages of the electron solvation and migration processes, leading to the formation of an internally solvated state, and the associated variations in the excitation spectra are described. The migration of the excess electron during the penetration is characterized by a nonhopping, polaronlike mechanism.

4007 Radiochemistry and Nuclear Chemistry

Refer also to citation(s) 7035, 7557, 7558, 7559

4008 Combustion, Pyrolysis, and High-Temperature Chemistry

Refer also to citation(s) 6642, 6693, 6928, 6939, 8122

8147 (CIM/S–CE-02846, pp. 12) **Conversion of +525^{0}C pitch by hydropyrolysis.** Pandey, R.N. (Guelph Chemical Labs., Guelph, ON (Canada)); Ingard, E.; Ternan, M. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference*. Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

Flash hydropyrolysis experiments have been performed on the vacuum bottoms fraction of Cold Lake bitumen, using zinc chloride as a catalyst. Milligram size samples of vacuum bottoms residue were heated rapidly (120-400^{0}C/s) by passing a large electric current through the reactor tube. The variables studied included temperature, heating rate, catalyst/pitch ratio, vapor phase residence time, and pressure. Temperature and catalyst/pitch ratio caused major changes in yields. In contrast, pressure had little effect. It was found that high conversions could be obtained at hydrogen pressures that are much lower than those normally used in catalytically hydrocracking residual oils. 15 refs., 10 figs., 3 tabs.

8148 (DOE/ER/13503–3) **Comprehensive mechanisms for combustion chemistry: An experimental and numerical study with emphasis on applied sensitivity analysis: Technical progress report, March 15, 1987–November 1, 1989.** Dryer, F.L. Princeton Univ., NJ (USA). Dept. of Mechanical and Aerospace Engineering. Nov 1989. 117p. Sponsored by U.S. DOE Energy Research. DOE Contract FG02-86ER13503. Order Number DE90003904. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

This research program is an integrated effort for determining the reaction mechanisms responsible for the oxidation of hydrocarbon structures under conditions representative of combustion environments. The experimental aspects of the program are presently conducted in a flow reactor facility which permits chemical kinetic observations at atmospheric pressure, in the temperature range of about 850 K to 1200 K, and for reaction times the order of 10 to 1000 msec. Specifically addressed is the oxidation and pyrolysis of ethanol, methanol, and formaldehyde. 129 refs., 27 figs.

8149 (STEV-FBT–89-40) **Dioxins from combustion. Their formation and destruction.** Miller, Harris (Lund Inst. of Tech. (Sweden). Dept. of Chemical Engineering). Statens Energiverk, Stockholm (Sweden); Lund Inst. of Tech. (Sweden). Dept. of Chemical Engineering. 1989. 71p. Project STEV-276-348. (LUTKDH-TKKT–1005-1-84). Order Number DE90728287. Available from NTIS (US Sales Only), PC A04/MF A01.

This licentiate thesis can be divided into two parts. The first objective was to optimize incineration parameters which would minimize dioxin emissions. This was achieved by correlating the destruction of polychlorinated dibenzo-p-dioxins (PCDDs) in the homogeneous gas phase with three independent parameters: gas temperature, residence time, and oxygen concentration. The second objective of this investigation was to verify the necessary gas temperature calculations with measurements using a laser spectroscopy method known as Coherent Anti-Stokes Raman Spectroscopy (CARS). The gas temperature measurements were then compared to the calculations based on the Nusselt equation. The following general statements can be drawn from this thesis. * Dioxins are destroyed under normal flame conditions. * Dioxins can survive normal flame temperatures when the oxygen concentration is similar to air. * Dioxin isomers resist further chlorination in the flue gas. Therefore, dioxin formation must occur from a ready chlorinated precursor such as chlorobenzene or chlorophenol. * Since dioxins are destroyed during combustion, they must be reformed as the flue gases are cooled. * Dioxin emissions can be reduced by lowering the flue gas temperature in electrostatic precipitators to 200 deg C. * Hausen's equation for the Nusselt number is valid. An appendix presents a literature survey, 72 refs.

8150 **A comparison of the velocity and scalar spectra in premixed turbulent flames.** Cheng, R.K. (Lawrence Berkeley Lab., CA (USA). Applied Science Div.); Shepherd, I.G.; Gokalp, I. *Combustion and Flame (USA)*, 78(2): 205-222 (Nov 1989). DOE Contract AC03-76SF00098.

Frequency spectra for scalar and two velocity components in premixed methane-air turbulent ν-flames and stagnation flow-stabilized flames have been measured using laser light Mie scattering and laser Doppler anemometry techniques. To assist in interpreting the influence of flame crossing phenomenon on the scalar spectra, theoretical predictions of the spectra developed by Bray-Libby-Moss and by Bray-Libby were evaluated. The spectral slopes and most energetic frequencies of the scalar spectra were compared with those of the velocity components normal and tangential to the turbulent flame brush. In both configurations, the spectra of the normal velocity components are similar to the corresponding scalar spectra, demonstrating the coupling between velocity and scalar spectra. However, the most energetic frequencies, which are related to the flame crossing frequencies, are about an order of magnitude higher in the ν-flame than in the stagnation flames. Because this difference does not seem to be proportional to the difference in the mean velocities, the results imply that the spatial scale distribution in the two flame zones are not the same.

8151 **Two-photon-excited stimulated emission from atomic hydrogen in flames.** Goldsmith, J.E.M. (Combustion Research Facility, Sandia National Laboratories, Livermore, California 94551 (US));. *Journal of the Optical Society of America B: Optical Physics (USA)*, 6(11): 1979-1985 (Nov 1989).

The first observation to the author's knowledge of optically excited stimulated emission in atomic hydrogen is described. The two-photon n=1→n=3 transition of hydrogen atoms in low-pressure flames is excited with 205-nm radiation produced by using a beta barium borate crystal to frequency mix the fundamental and frequency-doubled radiation from a 615-nm pulsed dye laser. The resulting 656-nm n=3→n=2 Balmer-α radiation is readily observable by eye as a coherent beam propagating in both the forward and reverse directions. A variety of characteristics of the stimulated emission are described, its behavior is compared simultaneous measurements of two-photon-excited fluorescence, and the possibility that the stimulated-emission process may affect the quantum yield of fluorescence and ionization detection methods is discussed. Potential diagnostic applications of two-photon-excited stimulated-emission detection for measuring atomic hydrogen in flames are demonstrated, using simultaneous profile measurements of stimulated emission and fluorescence signals.

8152 Crossed molecular beam study of the reaction $O(^3P)+C_2H_2$. Schmoltner, A.M. (Material and Chemical Sciences Division, Lawrence Berkeley Laboratory and Department of Chemistry, University of California, Berkeley, California 94720 (US)); Chu, P.M.; Lee, Y.T. *Journal of Chemical Physics (USA)*, 91(9): 5365-5373 (1 Nov 1989). DOE Contract AC03-76SF00098.

The reaction between ground state atomic oxygen and acetylene was studied using the crossed molecular beam method with an average collision energy of 6 kcal/mol. The two major primary reaction channels are (a) formation of CH_2 and CO and (b) formation of HCCO and H. Product angular distributions and time-of-flight spectra were measured and the translational energy release was determined for each channel. The reaction proceeds primarily on the triplet surface through a long-lived intermediate. For both channels the translational energy distributions were found to peak at about 30% of the total available energy, indicating the existence of an exit channel barrier in each case. The branching ratio between channel (a) and (b) was found to be 1.4 ± 0.5.

42 ENGINEERING

4202 Facilities, Equipment, and Techniques

Refer also to citation(s) 6956, 7103, 7466, 7489, 7803, 8133, 8351, 8353

8153 (BMU–1989-210) **Studies on sealing systems and tight containers for transport and storage of radioactive materials.** Schriftenreihe Reaktorsicherheit und Strahlenschutz. Ergebnisberichte, Untersuchungen, Studien, Gutachten. Weise, H.P.; Ecker, K.H.; Fessel, J.; Kowalewsky, H.; Wenz, R.; Wolk, T. Bundesministerium fuer Umwelt, Naturschutz und Reaktorsicherheit, Bonn (Germany, F.R.); Bundesanstalt fuer Materialforschung und -pruefung, Berlin (Germany, F.R.). 1989. 105p. (In German). Contract BMU St.Sch. 943. Available from Available from GRM Werbeberatung - Werbemittlung - PR, Eggenstein-Leopoldshafen, (Germany, F.R.).

The characteristics of different sealing systems applied in practice were investigated as to their limits of application, in order to facilitate the selection of the optimal systems for the respective cases of application and to determine safety reserves in the case of severe accidents. The following was investigated: (1) Elastomer sealings; measurement of the gas permeability due to permeation of elastomer sealings in dependence of sealing material, temperature and type of gas; comparison of permeation data for the ideal geometry of the plane-parallel plate and for the real geometry of O-rings; investigation of gas leakage at high temperatures until destruction of the sealing and at low temperatures until failure of the sealing system; measurement of the linear coefficient of expansion of elastomer materials as a function of temperature and determination of the gas transition temperatures; failure of the elastomer sealing at high gamma radiation loads. (2) Metal sealings (Helicoflex); measurement of the working characteristics of elastic metal sealings and determination of the operating points in the case of static stress; determination of leakage aggregates in the case of static stress; mechanical behaviour and gas leakage under periodic alternating load and under pulsating force. (orig./HP).

8154 (CESI–86-12) **Overvoltages and insulation coordination: special report for group 33 (Italy).** Thione, L. Centro Elecctrotecnico Sperimentale Italiano, Milan (Italy). Aug 1986. 10p. (CONF-8608233–: CIGRE international conference on large high voltage electric systems, Paris (France), 27 Aug - 4 sep 1986). Order Number DE89761907. Available from NTIS (US Sales Only), PC A02/MF A01.

Paper presented at international conference on large high voltage elctric systems (Paris, 27 Aug-4 Sep 1986).

In response to technological impacts on industry and the improvements made necessary in the reliability of electrical systems and cost-to-benefit ratios, some objectives are established: (1) the optimization of design performances of high voltage insulation; (2) the development of new materials (the use of metal oxides for surge arresters); (3) the improvements of laboratory testing techniques and the setting up of in-service diagnostics.

8155 (CESI–86-13) **Role of independent laboratory in Italy: present situation and future trends in electrical equipment test facilities.** Thione, L. Centro Elecctrotecnico Sperimentale Italiano, Milan (Italy). Jan 1986. 12p. (In Italian). (CONF-8601152–: Seminar on the reliability of power electronic equipment, Milan (Italy), 23-24 Jan 1986). Order Number DE89761909. Available from NTIS (US Sales Only), PC A03/MF A01.

Paper presented at seminar on the reliability of power electronic equipment (Milan, 23-24 Jan 1986).

This paper examines the planning of independent laboratories for the testing of electrical equipment. In particular, electronic systems for electric power transmission are treated. Different types of tests are also discussed. With regard to the field of power electronics in the transmission of electrical energy, the report cites the need for digital computers and analogic simulation capabilities for thyristor testing. Mention is made of plans for the construction (by CESI, Italy) of a large scale test facility suitable for reliability testing of large medium voltage electric motors used in nuclear facilities. The necessity for the design of accelerated aging test facilities is discussed with reference made to nuclear power plant equipment aging due to ionizing radiation absorption. In its assessment of the overall characteristics of a successful test facility, able to meet the demands of highly sophisticated technologies, the report cautions that increased product reliability and quality are greatly dependent upon a coordinated effort by all concerned parties - researchers, designers, fabricators and users.

8156 (CESI–86-14) **Medium voltage switchgear: Trends in design and construction technology.** Catenacci, G. Centro Elecctrotecnico Sperimentale Italiano, Milan (Italy). Jun 1986. 6p. (In Italian). (CONF-8606424–: Meeting on the future of low voltage and medium voltage switchgear, Pavia (Italy), 16-18 Jun 1986). Order Number DE89761908. Available from NTIS (US Sales Only), PC A02/MF A01.

Paper presented at meeting on the future of low voltage and medium voltage switchgear (Pavia, 16-18 Jun 1986).

Substations construction technologies are reviewed with particular emphasis given to the improved design of switching apparatus and their safety charcateristics. Non-conventional use of SF_6 is discussed with regard to requirements set by international standards.

8157 (CMRC–8902, pp. 162-169) **Development of a fluidized-bed calcining system.** Yagi, Masafumi (The Coal Mining Research Centre, Japan, Tokyo, Japan); Sekiwa, Tomikazu; Tatebayashi, Jun. Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

The newly developed fluidized bed calcining system was explained in summary. The cement calcining system by the new suspension preheater kiln, though widely used over the world, naturally inclusive of Japan, is problematic in low economicality, environmental pollution, etc, against which, by developing a new type fluidizied bed cement calcining system, it was planned to lower the production cost, heighten the product quality and doing others. In 1985, a large bench tester was constructed and used for a demonstration test, in addition to which a 20ton/d pilot plant is expected to be constructed. That system is composed of multi-stage cyclone preheating part, fluidized bed granulation furnace, fluidized bed calcining furnace, quick cooling use fluidized bed cooler and heat recovery use shifting bed cooler. That system is characterized by the possible use of low quality coal, easiness in exhaust heat recovery, possible heightening in quality of special cement, achievement of lowering in NOx and SOx content and possible large lowering in production cost. 5 figs., 1 tab.

8158 (Juel-Spez–512) **Analysis of operational possibilities and conditions of remote handling systems in nuclear facilities.** Angewandte Systemanalyse. Hourfar, D. Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Programmgruppe Systemforschung und Technologische Entwicklung; Essen Univ. (Gesamthochschule) (Germany, F.R.). Jul 1989. 220p. (In German). Order Number DE90732540. Available from NTIS (US Sales Only), PC A10/MF A01.

Accepting the development of the occupational radiation exposure in nuclear facilities, it will be showing possibilities of cost effective

reduction of the dose rate through the application of robots and manipulators for the maintenance of nuclear power plants, fuel reprocessing plants, decommissioning and dismantling of the mentioned plants. Based on the experiences about industrial robot applications by manufacturing and manipulator applications by the handling of radioactive materials as well as analysis of the handling procedures and estimation of the dose intensity, it will be defining task-orientated requirements for the conceptual design of the remote handling systems. Furthermore the manifold applications of stationary and mobil arranged handling systems in temporary or permanent operation are described. (orig.).

8159 (NAL-TR–981) **Development of the cryopanel for tests of xenon ion thrusters.** Hayakawa, Yukio; Miyazaki, Katsuhiro; Kitamura, Shoji; Obama, Toshio; Kajiwara, Ken'ichi. National Aerospace Lab., Chofu, Tokyo (Japan). Jun 1988. 32p. (In Japanese). Order Number DE89910142. Available from NTIS (US Sales Only), PC A03/MF A01.

This is a report (TR - 981, 1988) of National Aerospace Laboratory. A cryopanel suitable for testing xenon ion thrusters was designed and tested. The target temperature of the cryopanel was below 50K, since the vapor pressure of xenon was low enough at that temperature. This high temperature cryopanel has a cylindrical shape and was installed in the existing 1.5m diameter vacuum chamber. The cryopanel alone tests showed the attained temperature of the cryopanel was below 50K and the cryopanel could evacuate xenon with a pumping-speed of over 600,000 l/s. But while an ion thruster was operating, the speed fell to 40,000 l/s and the continuous operation time was restricted to about 90 minutes. It is very difficult to find other vacuum pumps that show the same performance in the same vacuum chamber and the same cost. 13 refs., 38 figs., 6 tabs.

8160 (ORNL/TM–11326) **Bilateral force reflection for teleoperators with masters and slaves with dissimilar and possibly redundant kinematics.** Jansen, J.F.; Babcock, S.M. Oak Ridge National Lab., TN (USA). Nov 1989. 49p. Sponsored by U.S. Department of Defense. DOE Contract AC05-84OR21400. Order Number DE90004392. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

Several bilateral control techniques and methods for exploiting redundant slaves are investigated as a part of research to develop and analyze bilateral, force-reflecting control methodologies for teleoperator systems with kinematic dissimilar masters and slaves. The study indicates that, with force/torque sensing at the wrist, and an impedance type of controller with the appropriate joint compensation, a significant improvement in performance and controllability of a teleoperator system can be achieved. 32 refs., 6 figs., 2 tabs.

8161 (SAND–89-1619) **Connector selection program implementation notes: Version 1.0.** Sevier, N.E. Sandia National Labs., Albuquerque, NM (USA). Nov 1989. 116p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. Order Number DE90004983. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The connector selection program is a database application that allows engineers to locate information about connectors that meet their requirements. This document describes the design and implementation of the database, the data input application, and the user interface. Nijssen's Information Analysis Methodology (NIAM) was used to characterize the connector data requirements which yielded the database design. This design was transformed into database record structures that were implemented in the relational database management software ORACLE. After the database was in place, data input screens were created to capture the connector data, analyze it, and place it in the proper database record structures. Finally, a user interface was designed and developed that displays or prints the information contained in the database, associated drawings, and documentation related to the program and its data.

8162 (SAND–89-1729C) **An introduction to shaker shock simulations.** Rogers, J.D. Sandia National Labs., Albuquerque, NM (USA). [1989]. 8p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-900145–1: 8. international modal analysis conference, Orlando, FL (USA), 29 Jan - 1 feb 1990). Order Number DE90003057. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The use of shakers in shock testing is addressed. A brief review of the shock response spectrum is given with its applications to test specification. The capabilities and limitations of shaker shock simulations are discussed with regard to both classical pulses and transient vibration inputs. Methods for performing shaker shock simulations are presented. 21 refs., 4 figs., 1 tab.

8163 (UCRL–21245) **Aerosol heating and vaporization of high-flux laser beams: Final report.** Armstrong, R.L.; Radziemski, L.J.; Park, B.S. New Mexico State Univ., Las Cruces, NM (USA). Dept. of Physics. May 1989. 6p. Sponsored by U.S. Department of Defense. DOE Contract W-7405-ENG-48. Order Number DE90003471. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Research under the contract "Aerosol Heating and Vaporization of High Flux Laser Beams" has emphasized theoretical modeling of laser-aerosol interactions and compared the results of some of the modeling calculations with experiment. When a high-irradiance laser beam propagates through the atmosphere a broad spectrum of interaction can occur. These range from linear scattering and absorption which occur at low irradiance, to Joule heating and vaporization, superheating, hydrodynamics, nonlinear optics and plasma formation which become significant as the irradiance increases. Of particular interest in this work are interactions which occur at moderate irradiance levels. By moderate we mean that those interactions occurring at higher irradiances such as plasma irritation, and strong hydrodynamic processes (shocks) may be neglected. In this work we have not considered nonlinear optical interactions. There remains the interactions centered around Joule heating and superheating together with the heat and mass transport processes which constitutes the response of the aerosol to these heating effects. Accordingly, our modeling efforts and comparison with experimental results have been restricted to those latter effects.

8164 **A damage model for ductile metals.** Bammann, D.J. (Sandia National Labs., Livermore, CA (USA)); Aifantis, E.C. *Nuclear Engineering and Design (Netherlands)*, 116(3): 355-362 (Sep 1989). (CONF-8708197–: 6. international seminar on inelastic analysis and life prediction in high temperature environment, Paris (France), 24-25 Aug 1987).

A physically-based theory of damage for ductile metals is outlined. It rests upon a direct extension of the authors recently proposed viscoplastic model for finite deformations to include the effects of dislocation-void interactions as they manifest themselves in void nucleation, growth, and coalescence. Emphasis is put on illustrating the general structure of the present framework within which coupling effects of texture development, void formation, and adiabatic heating can be considered and their role to the localization of deformation and failure can be evaluated. No special attention is placed on justifying the various growth laws and simplifying assumptions pertaining to the detailed structure of the model, for example the manner that spatial gradients of the damage variable enter into the theory. Such simplifications, however, facilitate the solution of the relevant equations for a case of homogeneous triaxial state of stress permitting a qualitative comparison with experimental data obtained for Bridgeman-notch specimens. (orig.).

4204 Heat Transfer and Fluid Flow

Refer also to citation(s) 7052, 7248, 7264, 7267, 7318, 7519, 7528, 7806, 8149

8165 (CIM/S–CE-02846, pp. 7) **Concentration measurements in pipelines containing flouring two-phase mixtures.** Sumner, R.J. (Univ. of Saskatchewan, SK (Canada)); McKibben, M.J.; Shook, C.A. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

Satisfactory interpretation of pipeline flow behavior for dispersed two-phase systems cannot be obtained from pressure drops and mean velocities alone. The concentration distribution of the dispersed (droplet or particle) phase in an emulsion or slurry must be known so than an appropriate model can be selected. Measurements with oil-in-water emulsion flows have shown that their pipeline flow behavior is similar to that which has been observed with solid particles as the dispersed phase. The measurements confirm that migration of particles away from the wall occurs at high concentrations of turbulently flowing dispersions. The mechanism producing this effect is not yet clear, but its effect upon pipeline flow would be significant. This investigation used intrusive probes to determine velocity and concentration distributions within pipes and a surface mounted probe for measurements at the pipe wall. Most of the measurements were made with solid particles, so that the dimension of the dispersed phase was constant and known. In turbulent flow, the velocity and concentration distributions were found to be nearly independent of mean velocity as long as gravitational effects were small. A region of low concentration of particles was observed at the pipe wall in most cases. The inward migration tendency increases with particle diameter and for finer particles concentration. 5 refs., 8 figs.

8166 (DOE/ER/13398–11) **Thickness, velocity, and temperature measurements in falling liquid films: Final report.** Mudawar, I.A.; Tiederman, W.G.; Lyu, Tae-Hwan; Houpt, R.A.; Koskie, J.E. Purdue Univ., Lafayette, IN (USA). Boiling and Two-Phase Flow Lab. Nov 1989. 153p. Sponsored by U.S. DOE Energy Research. DOE Contract FG02-85ER13398. Order Number DE90004290. Available from NTIS, PC A08/MF A01 - OSTI; GPO Dep.

Liquid films are encountered in many industrial applications such as heat exchangers and chemical process equipment. Therefore, there is significant interest in the prediction of heat and mass transport associated with film flow. As in any convective form of heat or mass transport, the fluid mechanics of the system strongly influence the resulting transport. This paper includes the results of experiments performed to define better the hydrodynamic characteristics of developing liquid films on vertical surfaces. In particular, this study provides data on water films at high Reynolds numbers (>10,000), and films of more viscous mixtures of water and propylene glycol. Statistical characteristics of film thickness that account for development length between 0.293 m and 1.913 m are presented over new ranges of Reynolds numbers and viscosities. Photographic analysis of film motion was also performed to investigate the three-dimensional structure of the waves.

8167 (JAERI-M–89-101) **The effect of the virtual mass force term on the stability of transient two-phase flow analysis.** Watanabe, Tadashi (Japan Atomic Energy Research Inst., Tokai, Ibaraki (Japan). Tokai Research Establishment); Hirano, Masashi; Tanabe, Fumiya. Japan Atomic Energy Research Inst., Tokyo (Japan). Aug 1989. 24p. Order Number DE90733142. Available from NTIS (US Sales Only), PC A03/MF A01.

The effect of the virtual mass force term on the stability of transient two-phase flow analysis is studied. The objective form of the virtual mass acceleration is used. The virtual mass coefficient is determined from the stability condition of basic equations against infinitesimal high wave-number perturbations. The parameter is chosen so that a reasonable agreement between the analytical and experimental sound speed in two-phase flows can be obtained. A one-dimensional sedimentation problem is simulated by the MINCS code which is a tool for transient two-phase flow analysis. The stability analysis is performed for the numerical procedure. It is shown that calculated results are stabilized so long as the virtual mass coefficient satisfies the stability condition of differential equations. (author).

8168 (N–89-17298, pp. 155-167) **Low-Reynolds-number two-equation turbulence model for predicting heat transfer on turbine blades.** Patankar, S.V.; Schmidt, R.C. National Aeronautics and Space Administration, Cleveland, OH (USA). Lewis Research Center. Oct 1987. (NASA-CP–2493;E–3745;NAS–1.55:2493;CONF-8710466–: Workshop on turbine engine hot section technology, Cleveland, OH (USA), 20-21 Oct 1987). In *Turbine Engine Hot Section Technology, 1987.* Available from NTIS, PC A20/MF A01.

A modified form of the Lam-Bremhorst low-Reynolds number kappa-epsilon turbulence model was developed for predicting transitional boundary layer flows under conditions characteristic of gas turbine blades. The application of the model to flows with pressure gradients is described. Tests against a number of turbine blade cascade data sets are included. Some additional refinements of the model that were made in recent months are explained.

4205 Materials Testing

Refer also to citation(s) 6977, 7471, 7481, 7568, 7569, 7579, 7592, 7731, 7900, 7953, 7971, 8009, 8014, 8263, 8600

8169 (ALS/TR–89-10) **Propagation of an unloading wave.** (O rasprostranenii volny razgruzki). Rakhmatulin, Kh.A. 21p. Translated from Prikladnaya Matematika i Mekhanika (USSR). *Prikladnaya Matematika i Mekhanika (USSR),* 9: 91-100 (1945). Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789.

The author investigates the propagation of deformation along a half-infinite bar due to sudden pressure beyond the limit of elasticity on its butt-end. The law of loading and law of unloading are supposed to be different. The following process of propagation of deformation is established. Starting from an instant of time the deformation of an element of the bar continuously increases up to a value following the law depending on the function $\sigma = \sigma(\epsilon)$ and then this deformation decreases following the law depending on the form of load as well as on the form of function $\sigma = \sigma(\epsilon)$. The value of deformation for the elements uniformly decreases along the length of bar starting from its butt-end. As a particular case of the function $\sigma = \sigma(\epsilon)$ the scheme of Prandtl is examined in the work. For this case, the distribution of residual deformation along the bar is found for an arbitrary change of load on the butt-end.

8170 (ENEL–410.100-27) **Betterment of line and station surface insulation reliability: use of statistical design criteria based on severity of environmental pollution.** Mantini, A.; Marinoni, F.; Marrone, G.; Porrino, A. Ente Nazionale per l'Energia Elettrica, Milan (Italy). Jun 1987. 11p. (In Italian). (CONF-8709394–: 88. annual meeting of the Italian Electrotechnical Association (AEI), Catania (Italy), 27-30 Sep 1987). Order Number DE89761894. Available from NTIS (US Sales Only), PC A03/MF A01.

Paper presented at 88th Meeting of the Italian Electrotechnical Association (Catania, 27-30 Sep 1987).

Through systematic research conducted in the natural environment and in the lab, ENEL (Italian National Electricity Board) has detailed probabilistic design criteria. This report examines: (1) the determination of the type and level of severity of the environmental pollution under investigation, (2) the choice of artificial test methods which best simulate pollution conditions, (3) the calculation, on a probabilistic basis, for each category of insulation (line, station, equipment), of the limit of resistance against life, (4) cycle service stresses, and (5) the determination, through lab tests or previously acquired service experience, of individual component dimensions of each category of insulator such that set limits of wear resistance are met.

8171 (INIS-mf–12035) **Introduction to the applications of computerized tomography in materials testing.** Technische Universitaet Berlin, Institut fuer Allgemeine Elektrotechnik. Technischer Bericht. Jaenchen, L.U. Technische Univ. Berlin (Germany, F.R.). Inst. fuer Allgemeine Elektrotechnik. Jul 1988. 33p. (In German). Order Number DE90732413. Available from NTIS (US Sales Only), PC A03/MF A01.

In this report, basic aspects of industrial computerized tomography were pointed out. In the first instance the mathematical theory was discussed. The problem of computerized tomography, the reconstruction of objects from their projections, could be easily defined for the continuous case. The reconstruction problem was clarified by examinations of the locus and spatial-frequency range. After discretisation, it provided approaches for reconstruction. After putting the theory into practice in technical plants, the image quality achieved had to be described. Important parameters were discussed. Finally, two computerized tomography systems operating with X-radiation were introduced. (orig.).

8172 (ORNL/FTR–3423) **[Irradiation of pressure vessel steels]: Foreign trip report, September 29–October 8, 1989.** Thoms, K.R. Oak Ridge National Lab., TN (USA). 23 Oct 1989. 12p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. 1886-8011-9B. Order Number DE90003947. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The traveler visited four West European research centers which have low to medium power research reactors capable of irradiating the wide variety of specimens of interest to the Heavy Section Steel technology program. At each site, the traveler toured the reactor facilities to determine compatibility with existing ORNL irradiation capsule designs and had discussions concerning feasibility and costs of conducting these irradiations at the respective sites. 7 refs., 2 figs.

8173 (ORNL/TM–10931) **An investigation of elastic guided waves for ceramic joint evaluation.** Simpson, W.A. Jr.; McClung, R.W. Oak Ridge National Lab., TN (USA). Oct 1989. 44p. Sponsored by U.S. DOE Conservation & Renewable Energy. DOE Contract AC05-84OR21400. Order Number DE90004400. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The rapid development of ceramic technology has led to the widespread use of ceramics in applications traditionally reserved for metals. Many of these applications, however, require the use of ceramics bonded to other ceramics or to metals in order to achieve the requisite strength. The presence of unbonding in such ceramic joints can now be reliably detected by previously developed ultrasonic techniques, but what is needed is a nondestructive approach which is capable of assessing bond strength directly. A possible tool to achieve this goal is the use of guided elastic waves propagating in the braze layer of a typical ceramic joint. We describe the theory of guided waves in the center layer of a general three-layer solid. The secular determinant is found, and roots of the secular equation are determined numerically for cases of interest in ceramic joining. Both guided and leaky modes are described, and it is shown that dispersive Stoneley waves can occur for these materials. In addition, the evanescent nature of the guided waves in the bounding solids raises the possibility of determining the elastic properties of the oxygen depletion layer adjacent to the braze in oxide ceramics. Possible models for incomplete bonding and the effect of this condition in the ultrasonic parameters are also discussed. 16 refs., 10 figs.

8174 (SAND–89-0507C) **Stability and fragmentation of ejecta in hypervelocity impact.** Grady, D.E.; Passman, S.L. Sandia National Labs., Albuquerque, NM (USA). [1989]. 16p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-891214–14: Hypervelocity impact symposium, San Antonio, TX (USA), 12-14 Dec 1989). Order Number DE90004087. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The present study offers an explanation for the behavior of debris ejected from the back surface of a target impacted by a high velocity projectile. Such debris is observed to expand as a ductile bubble and then fragment through surface instabilities when a critical expansion is achieved. An approximate model of hypervelocity impact developed by Swift et al. (1983), which assumes as expanding spherical shell of matter for the debris cloud, is introduced to motivate the analysis. We then solve for the spherically symmetric motion of, and pressures within, a spherical shell of ideal incompressible fluid subjected to inner and outer pressure boundary conditions. The solution is specialized to the freely expanding spherical shell (no pressure on the inner and outer boundaries). We then specialize further to the thin freely expanding spherical shell. Material response is extended to ideal incompressible plasticity and solutions for the radial and circumferential stress distributions are determined. Experimental results from high velocity impact tests of lead and uranium projectiles on lead and uranium targets using multiple flash radiography diagnostics (Grady et al., 1985) are compared with the theory. Although data are limited and the material and kinematic parameters somewhat uncertain, the comparison supports the physics and analysis put forth in this study. Similar comparisons are made between the analysis and computational simulations of the lead and uranium impact experiments. Again the results support the proposed mechanisms of initial inertial stability followed by plasticity-induced onset of instability and fragmentation. 13 refs., 12 figs.

8175 (UCRL–21243) **Feasibility study of using industrial robot for ultrasound testing: Final progress report.** Hsia, T.C. (California Univ., Davis, CA (USA). Dept. of Electrical Engineering and Computer Science). Lawrence Livermore National Lab., CA (USA); California Univ., Davis, CA (USA). Dept. of Electrical Engineering and Computer Science. 13 Feb 1989. 22p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. Order Number DE90002977. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The purpose of this program is to study the feasibility of employing an articulated industrial robot arm to perform ultrasound scanning of a work piece. The robot arm suitable for such application is the Unimation PUMA 560 manipulator with six degrees of freedom. This research is intended to study the basic properties of several issues which arise in the operations of the UTB facility at LLNL. These issues involve the understanding of control algorithms for collision-free motions of the robot arm with and without redundant kinematics, trajectory generation schemes for automated surface tracking based on 3D CAD/CAM model of the work piece, and the effective use of computer vision and ultrasound sensor to achieve position calibration of a work piece and on-line trajectory modification for accurate surface tracking. The robotics research laboratory at UC Davis has a research robotic system based on a six degrees-of-freedom Unimation PUMA 560 arm and a VAL-II controller. This system is used as a research tool for the investigation. 20 refs., 8 figs.

8176 (UCRL–21253) **Residual strain effects on large aspect ratio micro-diaphragms.** Hijab, R.S. (California Univ., Berkeley, CA (USA)); Muller, R.S. Lawrence Livermore National Lab., CA (USA). 30 Sep 1988. 8p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. Order Number DE90003928. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Highly compliant, large aspect ratio diaphragms for use in low-pressure, capacitive-readout sensors, have been investigated. In such structures, unrelaxed strain in the diaphragms can radically alter mechanical behavior. Although strain can be reduced by thermal annealing, it usually reaches a remnant irreducible minimum. The purpose of this paper is to describe techniques that result in low-strain materials and that reduce the effects of residual strain in micro-diaphragms. Square polysilicon grilles and perforated diaphragms made from both single and double polysilicon layers and from single-crystal silicon, with aspect ratios (side/thickness) of up to 1000 and very low compressive strain ($\approx 6 \times 10^{-5}$), have been fabricated. Strain reduction is achieved by combining thermal annealing with one of two mechanical design techniques. The first technique makes use of a series of cantilever beams to support the diaphragms. In a second procedure, corrugated surfaces in thinned membranes of single-crystal silicon are formed. The corrugations result from the use of boron doping and anisotropic silicon etching. In both of these techniques to produce low-strain diaphragms, an etched cavity is purposely formed in the substrate crystal below them. Only one-sided processing of wafers is employed, thus aiding reproducibility and providing ease of compatibility with an MOS process. A fast-etching sacrificial-support layer (phosphorus-doped CVD oxide) is used. 4 refs., 10 figs.

8177 **In-situ Moessbauer spectroscopy studies of phase transformations.** Fultz, B. (Univ. of California, Berkeley (USA)). *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 30 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

This talk begins with a brief general description of Moessbauer spectroscopy, and how it can be used to identify phases. Moessbauer spectra are obtained by counting individual radiations and the speed of data collection is limited by experimental considerations. Although conventional Moessbauer spectra collected over a range of energies can be used to follow sluggish phase transformations, the less conventional technique of tuning the spectrometer to selected energies allows phase analysis data to be obtained in only a few seconds. Examples in which in-site Moessbauer spectroscopy was used to follow phase transformations are drawn from the literature of ferrous alloys.

8178 **In-situ characterization: The properties perspective.** Morris, J.W. Jr. (Univ. of California, Berkeley (USA)). *TMS (The*

Metallurgical Society) Paper Selection (USA), 56: 30 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

The properties of structural materials–strength, ductility, and toughness–must fulfill the demands of the particular application for which they were produced. In many cases additional processing such as forming, joining, or the application of decorative or protective coatings is involved. Inasmuch as the properties of materials largely depend on microstructure, in-situ characterization during the finishing stages of production or by the customer can be used to ensure that the microstructure is appropriate. The utility of the various acoustic, magnetic, x-ray and other methods that are now available for laboratory and,in some cases, on-line analysis of microstructures and properties are discussed.

8179 **Measurement of surface free energies of solids.** Martinez, L. (National Univ. of Mexico); Schneibel, J.H. *TMS (The Metallurgical Society) Paper Selection (USA),* 56: 67 (Fal 1984). (CONF-840909–: TMS-AIME fall meeting, Detroit, MI (USA), 16-20 Sep 1984).

Annealing of cavitated polycrystalline metals and alloys at a low tensile stress σ_c results in sintering and growth, respectively, below and above a critical size $r_c \approx 2\gamma_s/\sigma_c$, where γ_s is the surface free energy. It is shown that r_c, and therefore γ_s, can be determined from the resulting shape change of the cavity size distribution. Optimum conditions for determining γ_s are suggested, and numerical solutions for typical experimental situations are presented.

4210 Combustion Systems

Refer also to citation(s) 6785, 6786, 6789, 6791, 6896, 7469, 7476, 8167

8180 (CANWEC–CE-02832, pp. 31) **Advances in the combustion of fossil fuels: Report 2.3.2. .** Allen, J.W. (NEI International Combustion Ltd., Derby (UK)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02832). In *Energy for tomorrow. Division 2: Energy and the environment: Session 2.3: environmental concerns: The role of technology.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Recent advances in the combustion of fossil fuels have been made as a result of increasing worldwide pressures for control of emissions to the atmosphere, particularly from powerstation boilers. Modification to combustion system design and methods of operation has enabled significant reductions in the emissions of nitrogen oxides (NO_x). Chemical injection into the combustion system has been suggested both as a means of NO_x and also sulphur dioxide SO_2 emission reduction. SO_2 emission cannot be controlled by combustion modification. Increased efficiency processes involving fluidised bed combustion in combined cycle operations offer in addition to NO_x and SO_x control some short-term control on the emission of carbon dioxide and its subsequent role in the greenhouse effect. Typical designs and operation of low NO_x emission burners are discussed in the context of power station boiler operation and an attempt to assess the ultimate level of NO_x reduction by combustion modification is made. Fluctuations in world fuel prices have stimulated the search for alternatives or modifications to the prime fossil fuels used in power generation. Recent developments in the utilisation of coal liquid mixtures and heavy hydrocarbon emulsion fuels are discussed in this context. To further the understanding of the modified combustion processes an increasing use is being made of mathematical modelling. However, in order to validate these models non-intrusive investigative techniques; particularly in the near burner region of the flames, are required. Laser based techniques are under development to provide this accurate and detailed information. 12 figs., 17 tabs.

8181 (CMRC–8901, pp. 331-345) **Development of internally circulating type fluidized-bed combustion boiler.** Oshita, Takahiro (Ebara Corp., Tokyo, Japan); Higo, Tsutomu. Coal Mining Research Centre, Tokyo (Japan). Aug 1987. (In Japanese). In *Proceeding of the 9th Presentation Meeting on Coal Utilization Technology.* Order Number DE90725021. Available from NTIS (US Sales Only), PC A19/MF A01.

Structures, functions, features and some experimental data of the coal fired internally circulating type fluidized-bed combustion boiler was presented, which was developed on the basis of the technology and knowhow of TIF (twin interchanging fluidized-bed) revolving fluidized-bed incinerator for refuse or sludge. The boiler was featured by a main bed cell and heat recovery cell separated by a inclined separator, and the capability of circulating bed materials as desired in the boiler. Following features were achieved by such structures: a wider turndown width, the minimum corrosion and erosion of immersed heating surfaces, simple boiler structures, excellent load characteristics, the mixed combustion of industrial wastes, and the efficient combustion of a variety of coal types by a single fluidized-bed combustion boiler. In experiments, a natural/forced circulation drum boiler of 2t/h and a screw coal feeder were used. As a result, steady combustion was obtained ranging from various coals with different coal ranks to lowest grade coal washing sludge of 1,200kcal/kg in calorific value. 7 refs., 26 figs., 1 tab.

8182 (CMRC–8902, pp. 296-307) **Present status on Swedish development of pressurized fluidized bed combustion (PFBC) combined power plant.** Kageyama, Akihiro (Gaderius Energy, Tokyo, Japan). Coal Mining Research Centre, Tokyo (Japan). Aug 1988. (In Japanese). In *Proceeding of the 10th presentation meeting on coal utilization technology 1988.* Order Number DE90725042. Available from NTIS (US Sales Only), PC A18/MF A01.

This paper presents the pressurized fluidized bed combustion (PFBC), and its present state in USA and Spain are introduced. The technique of the PFBC almost comes in practice at present, and the PFBC plant is under construction in Sweden. The features of the plant are combined cycle power generation adopted gas turbine and its small dimensions. In ABB Carbon, as 15 Mwt pilot plant is running for 6000-hour, the PFBC is represented by the process of coal combustion cycle power generation combined with pressure bubble type fluidized bed and gas turbine. The PFBC is the most suitable plant to improve power plant currently in use, has excellent performance in environmental problems, and the combined cycle power generation is capable to increase 15-30% in output, also to improve less than 6% in plant efficiency. Installation of the 2000 Mw PFBC plants are determined in both countries, USA and Sweden. 7 refs., 3 figs., 6 tabs.

8183 (CPS–40-11/14-1989E) **Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.** Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. 1684p. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

A conference sponsored jointly by Environment Canada and the US Environmental Protection Agency was held in order to provide an effective international forum for the transfer and exchange of technical information on municipal solid waste (MSW) incineration and ash treatment/disposal. The conference proceedings include papers examining relevant technical, regulatory, and social issues from the perspective of defining problems and proposing solutions, as well as describing experiences, forecasting trends, and reporting new and improved technologies. Papers were presented in the following broad subject areas: international overviews; MSW combustion planning and maintenance; ash characterization and leaching; risk and health effects; waste combustion performance; ash treatment, utilization, and disposal; sampling and analysis; residue issues and research needs; combustion technology; economic and social issues; flue gas cleaning; materials recovery and recycling; quality assurance/quality control; and challenges of the 1990s. Separate abstracts have been prepared for 38 papers from this conference.

8184 (GKYA–7218DD71) **Study of flue, furnace and envelope parameters affecting oil furnace start-up spillage.** Yuill

(G.K.) and Associates Ltd., Winnipeg, MB (Canada). 18 Feb 1988. 70p. (MICROLOG–89-04333). Available from PC Canada Mortgage and Housing Corporation, Annex Bldg., 628 Montreal Rd., Ottawa, ON, CAN K1A 0P7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

The first part of this study investigates the parameters of envelopes flue, furnace and envelopes, that can affect the start-up spillage of an oil furnace. The transient furnace-flue system performance after firing was simulated using the heating system simulation program FLUESIM. As a basis for comparison, this study uses a 127 mm standard A-vent. The effect of different house backpressures on start-up is given. The study concentrates on the time it takes the flue to overcome initial spillage under a number of different conditions and comes to conclusions about: interior vs exterior flues, flue height, flue lining, effect of an initial induced backdraft; thermal inertia of flues, thermal insultation of flues: air/fuel ratio in the furnace; area and position of the barometric damper; sizes of the combustion chamber and heat exchanter; stack gas temperature; thermal insulation of the vent connector; effect of a draft-inducing fan; area of fresh-air intake; and outer ambient temperature. The second part of this study investigates by the same means the time and height extent of flue condensation for different flue parameters. 33 figs.

8185 (OH/RD–88-213-K) **NO_x formation and control during fossil-fuel combustion.** Nothrup, F. Ontario Hydro Research Div., Toronto, ON (Canada). 14 Sep 1988. 45p. (MICROLOG–89-04441). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

The emission of NO_x (NO and NO_2) into the atmosphere, as a result of fossil-fuel combustion, is of concern because of its potential effect on the environment through acid rain and through its role in ozone formation and the subsequent effects on vegetation. In view of this, a comprehensive survey of the available information on the various NO_x formation and destruction mechanisms occurring during fossil-fuel combustion has been carried out. This information has been used to review the methods available for NO_x reduction, including both in-furnace NO_x removal techniques and flue gas treatments. Combustion modification techniques have been found to provide the simplest and most economical method of control when conditions allow for their use and when only a moderate NO_x removal efficiency is required. Flue gas treatments are more efficient means of reducing NO_x emissions, especially for existing facilities, since combustion modification is not highly effective in retrofit situations. The most efficient flue gas treatment technique is selective calalytic reduction. Other methods of lower efficiency or greater technical complexity are described as well. Suggestions for research into possible future NO_x reduction techniques are also put forth. 82 refs., 3 tabs.

8186 (RPC–MDP/88/17) **Inverstigaton of sulphur capture during circulating fluidized bed combustion of eastern Canadian coals. Phase 2: Volume 1. Final report.** Chalkley, MF; salib, P.F.; Robson, K.R. Research and Productivity Council, NB (Canada). 20 Mar 1989. 187p. Contract DSS 23440-7-9063/01SQ. (MICROLOG–89-04484). Available from PC Canada Centre for Mineral and Energy Technology, Technical Information Division, 562 Booth St., Room 20C, Ottawa, ON, CAN K1A 0G1; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

This is the final report on phase 2 of the investigation of sulphur capture using New Brunswick and Nova Scotia limestones during circulating fluidized bed combustion of eastern Canadian coals. The parameters tested were limestone type and particle size, Ca/S ratio, bed temperature, operating velocity, secondary cyclone recycle, and solid circulation rate. The effect of each of these parameters on sulphur capture has been identified. Pressure drop measurements were carried out and the effect of the J-valve performance on the solids loading in the combustor was examined. Burning Minto coal with Havelock limestone at a Ca/S ratio of 2:1, sulphur emissions were reduced by 87% with recycling of the dust from the secondary cyclone back into the combustor. At the same Ca/S ratio and without dust recycling, the highest attainable sulphur capture was only 76%. For Prince coal and Windsor limestone, higher sulphur capture was possible, using the same Ca/S ratio and, without dust recycling, a sulphur capture of 93% was achieved. A correlation of these results with those from the New Brunswick Power demonstration unit at Chatham will be made when these become available. A number of conclusions have been drawn: the most effective limestone particle size range was identified (40 to 600 mm), the importance of dust recycling was highlighted and the sorbents tested were ranked. One of the important future tasks would be to evaluate different options for improving sulphur capture and sorbent utilization. 5 refs., 32 figs., 13 refs.

8187 (VTT-SYMP–98, pp. 91-139) **Some specific features and the most modern solutions for dryers of very moist fuels.** Kislev, A.V. (Vsesojuznyj teplotehnitceskij institut im. Dzerzhinskogo (USSR)); Ivanov, J.N. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (In Finnish, Russian). (CONF-8701165–: Seminar on comparison of drying methods of wet coal and peat, Jyvaeskylae (Finland), 6 Jan 1987). In *Comparison of drying methods of wet coal and peat.* Order Number DE90728211. Available from NTIS (US Sales Only), PC A09/MF A01; NTIS (US Sales Only), PC A09/MF A01.

At present many power plants in the USSR get fuel of much weaker quality than they were planned for. The decrease of quality is due to the increase of ash and moisture contents of the fuel. Coal wet processing waste sludge is also delivered to some power plants. The mixture of coal of poor quality and sludge is very moist, coal fines, flow properties of which are poor, and which tend to block and stuck into the fuel feeding and dust preparation systems, and to arch into the unloading funnels and silos. The use of fuel of poor quality causes serious troubles also for the operation of boiler itself, due to increase of fuel consumption, the increased of moisture to be evaporated from milling equipments, the decrease of efficiency of combustion processes in furnaces, due to increases content of moist drying media in the fireplace, the decrease of efficiency of the boiler, which again increases the fuel consumption. The most efficient way to remove difficulties caused by decrease of the fuel quality is the preliminary drying of the fuel. Open drying systems, there the moisture of the fuel does not reach the boiler, are preferred in the USSR, there the completely open fuel dust systems are used. The drying equipments are also developed further, because the traditional dryers mills are not always effective enough in drying. In this presentation the results of different industrial fuel dust production methods are discussed, as well as the improvement of drying equipments of coal of poor flow properties and work done with development of new equipments.

8188 (VTT-SYMP–98, pp. 60-90) **Fluidized-bed steam drying of milled-peat at a heating power plant.** Jahkola, A. (Helsinki Univ. of Technology, Espoo (Finland)); Huhtine, M. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (In Finnish, Russian). (CONF-8701165–: Seminar on comparison of drying methods of wet coal and peat, Jyvaeskylae (Finland), 6 Jan 1987). In *Comparison of drying methods of wet coal and peat.* Order Number DE90728211. Available from NTIS (US Sales Only), PC A09/MF A01; NTIS (US Sales Only), PC A09/MF A01.

If milled peat is dried with superheated steam, the steam evaporated from the peat can be condensed under 1 bar pressure at 100 degr. Celsius temperature level. If the dryer is based on fluidized-bed technique, the profitable heat transfer properties of fluidized-bed can be used. The fluidized-bed steam dryer can be integrated to the heating power plant by heating the fluidized-bed indirectly with the bled steam of the turbine and the condensate can be recirculated into the feed water tank. The steam evaporated form the milled peat is led to the district heat exchanger fro delivering the heat to the district heating water. The fuel savings are about 10% compared with a plant with flue gas dryer. Steam drying may result a more economic use of milled peat than today.

8189 (VTT-SYMP–98, pp. 155-186) **Some Finnish flue gas dryer types.** Linna, V. (Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). Dotimaisten Polttoaineiden Lab.). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (In Finnish, Russian).

(CONF-8701165–: Seminar on comparison of drying methods of wet coal and peat, Jyvaeskylae (Finland), 6 Jan 1987). In *Comparison of drying methods of wet coal and peat.* Order Number DE90728211. Available from NTIS (US Sales Only), PC A09/MF A01; NTIS (US Sales Only), PC A09/MF A01.

Great variation in moisture content is the main source of operational interferences in milled peat and bark fueled power plants. Flue gas drying is widely used as a method for quality improvement, so that the moisture content may be held constant and the combustion process stable. In this presentation some flue gas dryer types, used in Finnish milled peat and bark fueled power plants, are viewed and operational experiences of them discussed.

8190 (VTT-SYMP–98, pp. 140-154) **District heating power plant at Jyvaeskylae.** Janka, P. (Tampella Oy, Tampere (Finland)). Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (In English, Russian). (CONF-8701165–: Seminar on comparison of drying methods of wet coal and peat, Jyvaeskylae (Finland), 6 Jan 1987). In *Comparison of drying methods of wet coal and peat.* Order Number DE90728211. Available from NTIS (US Sales Only), PC A09/MF A01; NTIS (US Sales Only), PC A09/MF A01.

The Rauhalahti power plant near the town Jyvaeskylae distributes district heat to the town, process steam to a paper mill and supplies energy to the Finnish grid. The boiler represents a peat fired boiler of the second generation, in which most of the drying gas bypasses the boiler. Coal is used as support and reserve fuel.

4220 Mining and Underground Engineering

Refer also to citation(s) 6837, 6933

8191 (CIM/S–CE-02846, pp. 9) **Critical review of the application of horizontal wells.** Nzekwu, B.I. Canadian Inst. of Mining and Metallurgy, Regina, SK (Canada). 1989. (CONF-8909278–: 3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM, Regina (Canada), 25-27 Sep 1989; CE–02846). In *Third Saskatchewan petroleum conference.* Available from Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN.

Horizontal well technology is still not well understood and still requires considerable improvements. Many field applications have not provided the extraordinary production increases that were expected. This review of the state of the art of horizontal well technology focuses on the shortcomings in the knowledge base in such areas as drilling, well completion, logging, cementing, sand control, fracturing, recovery strategies, and reservoir performance predictions. Various field results and experiments have been evaluated and compared to the expectations based on literature publications. A set of recommendations is proposed of areas requiring further research and development. 4 refs., 6 figs.

8192 (CRIE-U–87086) **Triaxial test on the strength characteristics of hard rock with stiff loading machine.** Nakagawa, Kameichiro; Nozaki, Takashi; Hibino, Toshi. Central Research Inst. of Electric Power Industry, Abiko, Chiba (Japan). Oct 1988. 31p. (In Japanese). Order Number DE89910265. Available from NTIS (US Sales Only), PC A03/MF A01.

In order to accurately evaluate the safety of excavated cavern and to carry out the rational reinforcement required for the diversification and large scale utilization of underground spaces, it is required to more strictly evaluate mechanical properties of rock including the residual strength. This report described outline of the testing equipment for rock residual strength composed of a stiff triaxial loading machine developed to obtain basic data and the testing method nd tested results for the rock strength. This test apparatus has a high stiff loading frame and also a electro-hydraulic servo-controlled system so that strain controlled compression test can be performed more accurately and the post failure behavior can be tested precisely. This test apparatus was applied to the multi stage triaxial compression test to granite cores, the strength test of cores containing the weak plane and the results were described along with the consideration. 3 refs., 21 figs., 2 tabs.

8193 (MSHA/IR–1168) **Injury experience in sand and gravel mining, 1987.** Mine Safety and Health Administration, Denver, CO (USA). 1988. 116p. Sponsored by U.S. Department of Labor. Order Number DE90003741. Available from NTIS, PC A06/MF A01 - OSTI.

This Mine Safety and Health Administration (MSHA) informational report reviews in detail the occupational injury and illness experience of sand and gravel mining in the United States for 1987. Data reported by operators of mining establishments concerning work injuries are summarized by work location, accident classification, part of body injured, nature of injury, and occupation. Related information on employment, worktime, and operating activity also is presented. Data reported by independent contractors performing certain work at mining locations are depicted separately in this report. For ease of comparison with other metal and nonmetallic mineral mining industries and with coal mining, summary reference tabulations are included at the end of both the operator and the contractor sections of this report. 3 figs., 38 tabs.

8194 (MSHA/IR–1192) **Injury experience in sand and gravel mining, 1988.** Mine Safety and Health Administration, Denver, CO (USA). 1989. 110p. Sponsored by U.S. Department of Labor. Order Number DE90003733. Available from NTIS, PC A06/MF A01 - OSTI.

This Mine Safety and Health Administration (MSHA) informational report reviews in detail the occupational injury and illness experience of sand and gravel mining in the United States for 1988. Data reported by operators of mining establishments concerning work injuries are summarized by work location, accident classification, part of body injured, nature of injury, and occupation. Related information on employment, worktime, and operating activity also is presented. Data reported by independent contractors performing certain work at mining locations are depicted separately in this report. For ease of comparison with other metal and nonmetallic mineral mining industries and with coal mining, summary reference tabulations are included at the end of both the operator and the contactor sections of this report. 3 figs., 38 tabs.

8195 (MSHA/IR–90003748) **Annual report of the Secretary of Labor under the Federal Mine Safety and Health Act of 1977, fiscal year 1983.** Mine Safety and Health Administration, Denver, CO (USA). [1983]. 175p. Sponsored by U.S. Department of Labor. Order Number DE90003748. Available from NTIS, PC A08/MF A01 - OSTI.

In fiscal year 1983, the Department of Labor's Mine Safety and Health Administration (MSHA) continued to consolidate organizational changes made the year before to improve safety and health programs affecting nearly 402,000 workers at 18,190 mines and mineral processing plants. The Mine Safety and Health Administration is the Federal agency with responsibility for assuring that the nation's miners go to work daily in safe and healthful environments. The Agency's jurisdiction ranges from small mines with few employees to large companies employing hundreds of workers, both underground and surface, and producing such diverse products as coal, silver, gold, salt, limestone, potash, iron, uranium, sand, gravel and many other highly useful substances.

8196 (MSHA/IR–90003750) **Annual report of the Secretary of Labor under the Federal Mine Safety and Health Act of 1977: Fiscal year 1981.** Mine Safety and Health Administration, Denver, CO (USA). [1989]. 87p. Sponsored by U.S. Department of Labor. Order Number DE90003750. Available from NTIS, PC A05/MF A01 - OSTI.

In FY 1981, the Labor Department's Mine Safety and Health Administration (MSHA) was responsible for safeguarding some 536,000 workers at 21,000 US mines and mineral processing plants. These included underground and surface operations producing such diverse minerals as coal, silver, potash, gold, salt, limestone, iron, uranium, sand and gravel. In size, they ranged from small mines with a handful of employees to operations employing hundreds. An industry with unique hazards, mining is all the more dangerous became the work environment changes constantly. In underground mines, potential hazards include falls of the mine roofing, flooding, and toxic or explosive gases. A fire or explosion in the confined underground environment can mean disaster. Whether underground or on the surface, today's mechanized mines also contain high-voltage electricity, explosives, powerful mining machinery and fast-moving haulage equipment. Potential health hazards may include dusts that cause lung disease, deafening noise, radiation and toxic chemicals. 6 figs., 38 tabs.

4230 Marine Engineering

Refer also to citation(s) 6827, 6835, 6836, 6848, 8611

8197 (EPRI-EL–6411) **Far-infrared laser inspection system for cable: Final report.** Cheo, P.K. (United Technologies Research Center, East Hartford, CT (USA)); Farina, J.D.; Rubino, R.A. Electric Power Research Inst., Palo Alto, CA (USA); United Technologies Research Center, East Hartford, CT (USA). c Nov 1989. 101p. Sponsored by Electric Power Research Institute. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

A laser scanner prototype has been developed for production line inspection of voids and contaminants in cross-linked polyethylene insulation which is extruded over the conductor employed in the underground electric power distribution network. This prototype consists of a far-infrared laser operating at a laser wavelength of 118.8 μm, a high-speed (0 to 9000 rpm) optical scanner, and an electronic controller and signal processor. This laser/cable inspection system is fully automated and has been successfully laboratory tested. 7 refs., 21 figs.

8198 (NEI-NO–100, pp. 14) **Efficient operations and maintenance of platforms in the North Sea.** Villaboe, M. (Norwegian Marine Technology Research Institute, Trondheim (Norway)). Norges Teknisk-Naturvitenskapelige Forskningsraad, Oslo (Norway). 1989. (CONF-8906258–: 1989 NTNF oil and gas conference, Oslo (Norway), 13-14 Jun 1989). In *Norwegian oil and gas in a low-price market.* Order Number DE90728220. Available from NTIS (US Sales Only), PC A12/MF A01.

The paper is highligting a few aspects of efficient operation and maintenance in the offshore industry. It is focusing on maintenance, because maintenance is the single most important cost factor. Maintenance is also a factor with potentials for further reduction, especially in the design process, where most of the boundary conditions for maintenance is settled. Operational efficiency improvements of existing platforms can be obtained mainly through implementation of improved planning and follow-up methods and procedures. Technologically this is strongly linked to condition monitoring, diagnosis and decision support functions both as integral functions in maintenance planning and as elements of operational monitoring and control. In order to reduce corrective and unforeseen maintenance actions for processes with production availability and safety consequences redundancy has to be built into processes with random type of failure mechanisms. For processes with predictable failure mechanisms one can select either to build in redundancy or to implement condition monitoring with prediction functions in order to do maintenance at preplanned occasions. The key factor here is to have reliable prediction functions and decision support functions that can increase the maintenance planning horizon. In the field of operational and maintenance research, for the offshore industry, the oil companies have the latest years given this high priority and improvements can already be seen in terms of reduced operating costs. It is thus very likely that the operating cost prognosis prepared by Norwegian Petroleum Directorate (NPD) will be reduced somewhat. 9 figs.

8199 (NEI-NO–100, pp. 11) **Platform manning levels in the North Sea; Can they be reduced?.** Guerrero, V. (Norwegian Petroleum Consultants A.S., Asker (Norway)); Laading, G. Norges Teknisk-Naturvitenskapelige Forskningsraad, Oslo (Norway). 1989. (CONF-8906258–: 1989 NTNF oil and gas conference, Oslo (Norway), 13-14 Jun 1989). In *Norwegian oil and gas in a low-price market.* Order Number DE90728220. Available from NTIS (US Sales Only), PC A12/MF A01.

This presentation summrizes the results of a study undertaken by Norwegian Petroleum Consultants A.S. for Esso Norge a.s. to establish the potential for reduction of offshore production platform manning in Norway. The study establishes that a significant potential exists for offshore manning reduction in future installations, recognizes that it is possible to achieve part of this potential, and recommends how to approach its implementation. The study considered actual data for 35 platforms or complexes, 22 North Sea, representing ten operators; and 13 international, all operated by Esso affiliates. An analysis of manning level was made as a function first of production capacity and subsequently of topside weight. The North Sea data showed manning to be moderately proportional to each of the variables. The significant variations in individual manning levels however, confirmed erratic but frequent examples of overmanning. The international data showed manning levels to be nearly constant over limited range of production capacities and topside weights. The survey, although limited in scope, was adequate to illustrate that offshore crews need not be as large or varied in their numbers as the North Sea examples illustrated. It confirmed that some North Sea installations are overmanned. 2 tabs.

8200 (STF–71A89010) **Ultimate strength testing of cracked tubular joints.** Eide, O.I.; Berge, S.; Granli, T. SINTEF, Trondheim (Norway). Jun 1989. 61p. Order Number DE90728267. Available from NTIS (US Sales Only), PC A04/MF A01.

Tubular T-joints with chord diameter 508 mm and plate thickness 20 mm were tested in out of plane bending and axial loading. Defects simulating fatigue cracks of various sizes were introduced at the chord weld toe and in the welds. The tests were performed at 10°C. Fracture of all specimen occured by extensive ductile tearing. The ultimate strength and ductility of the tubular joints were only negligibly influenced by the cracks. 7 refs., 26 figs., 3 tabs. (Author).

8201 (STF–71A89034) **Reliability analysis of a fixed jacket platform: Ultimate limit state.** Olufsen, A.; Moan, T. SINTEF, Trondheim (Norway). Dec 1988. 109p. Order Number DE90728268. Available from NTIS (US Sales Only), PC A06/MF A01.

A component ultimate limit state reliability analysis is performed for a specific North Sea jacket platform. A slightly re-designed version of the jacket is also considered for assessment of the inherent reliability level of the relevant design code, i.e. Norwegian Petroleum Directorate and Det norske Veritas. Uncertainties related to load effects, capacity formulas, material and geometrical properties are quantified. These uncertainties are then used in a second order reliability method to estimate measures of safety (β, P_f) for a selected set of structural components (tubular columns and joints). The approach employed is the basis for a probabilistically based procedure for assessing load factors. Finally, sensitivity of reliability measures to perturbations of basic distribution parameters were investigated. 23 refs., 17 figs., 27 tabs. (OH).

4250 Power Cycles

8202 (CANWEC–CE-02836, pp. 19) **Organic vapor turbogenerators using locally available heat sources: 25 years of industrial experience: Report 4.1.10.** . Bronicki, Y.L. (Ormat Turbines Ltd., Yavne (Israel)). Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02836). In *Energy for tomorrow. Division 4: Energy and technology: Session 4.1: Energy research and development and other major energy technology issues.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

The paper examines how Ormat Turbines Limited can use locally available and pollution-free heat energy sources to produce electricity. In many sites around the world non-fossil alternative energy sources are locally available: water-dominated low-to-moderate-temperature geothermal sources, solar energy, biomass and exhaust waste heat. One alternative field-proven technology available today is that of organic vapor turbogenerators which in many cases is already economically competitive. In many such applications modular geothermal power plants and solar pond power plants have been field tested and practical operational experience containerized organic vapor turbogenerator is used to convert moderate-temperature heat into electrical power. This key element of the two systems is now a mature technology, having been developed by Ormat since 1965. After a short description of the technology a number of practical applications and field experiences are presented, among others the power plants of combined 100 MW capacity in the USA, as well as projects under construction in Iceland, New Zealand, and Hawaii. 10 refs., 10 figs.

4260 Components, Electron Devices and Circuits

Refer also to citation(s) 7545, 7823, 7869, 8057, 8072, 8074, 8159, 8349, 8600, 8907, 8987

8203 (SAND–89-0782) **Sintering studies on high field varistors.** Garino, T.J.; Tuttle, B.A.; Harrington, M.S.; Yio, J.L. Sandia National Labs., Albuquerque, NM (USA). Oct 1989. 31p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. Order Number DE90002626. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

We studied the sintering behavior of high field chem-prep ZnO varistors using dilatometry and determined how sintering conditions influence the varistor's electrical properties. The dilatometric results indicated that 95% theoretical densities could be obtained with a soak time of only 0.5 hour above 752°C, using a 3°C/min ramp rate; greater shrinkage did not occur for soak temperatures above 752°C. A variety of soak times and temperatures was found to be capable of producing varistors with acceptable electrical properties. The variation in the switching field, E_s (at a current density of 10 A/cm^2), with soak temperature was found to be significantly less for short soak times than for the standard 16 hour soak time. Annealing sintered pellets at 700°C for 4 hours raised the nonlinearity coefficients by ~25% and decreased E_s by ~10%. This uniform decrease in E_s led to a further reduction in the slope of E_s vs soak temperature for values of E_s in the specified range of interest. Further testing of more samples, of samples from different powder batches, and of samples annealed at various temperatures needs to be performed to verify these results. 19 refs., 10 figs., 1 tab.

8204 (SAND–89-2374C) **Power semiconductor devices for space nuclear power systems.** Loescher, D.H. (Sandia National Labs., Albuquerque, NM (USA)); Dawes, W.R. Jr. Sandia National Labs., Albuquerque, NM (USA). [1989]. 6p. Sponsored by U.S. Department of Defense; U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-900109–9: 7. symposium on space nuclear power systems, Albuquerque, NM (USA), 7-11 Jan 1990). Order Number DE90001178. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Silicon power diodes, transistors, thyristors and other devices can be damaged by elevated temperatures, temperature cycling, and radiation. In this paper we discuss the vulnerability of devices that integrate bipolar and MOSFET (metal-oxide-semiconductor-field-effect transistor) devices onto a single chip. Such devices offer the advantages of good current carrying capability that is characteristic of bipolar structures and high impedance control nodes that are characteristic of MOSFET devices. Devices located near a space-based fission power source will be subjected to high temperatures, temperature cycling, naturally occurring radiation, radiation from the reactor; and these devices may be subjected to radiation from or caused by weapons used to attack the power source. Damaging radiation includes electrons and protons trapped in naturally occurring radiation belts, electrons pumped into these belts as a result of nuclear explosions, cosmic rays, neutrons from the reactor, and high energy photons (gamma rays and x-rays). 3 refs., 2 figs.

8205 (SCBC–89-03687) **Superconductivity committee planning report.** Science Council of British Columbia, Victoria, BC (Canada). Nov 1988. 103p. (MICROLOG–89-03687). Available from PC British Columbia Legislative Library, Government Documents Division, Parliament Buildings, Victoria, BC, CAN V8V 1X4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

The recent discovery of superconductors that operate at relatively high temperatures has generated a large amount of research which promises to have applications in almost all branches of high technology, notably those in which high electric current densities are used. After a background description of the properties of superconductors, the market for superconductor technology is described from the Canadian perspective. Worldwide markets are growing rapidly and are estimated to total $920 million by 1990, considering only conventional low-temperature superconductors. Applications for superconductivity include the use of thin films and microelectronics, low loss signal transmission, tunnel injections, and sensitive magnetic detectors. Superconducting magnets find application in magnetic separation, magnetic levitation and propulsion, and for energy storage and transmission by power utilities. Research in superconductivity in British Columbia, reviewed in this report, has been under way at 3 universities and 4 or 5 compaines, where a small group of qualified researchers and some high-technology laboratories are focusing on thin-film and electonic applications. The potential market for superconductivity is felt to warrant more effort in British Columbia, and a number of recommendations are made for coordinating and promoting research, funding joint university-industry projects for innovative applications, and facilitating technology transfer.

8206 (UCRL–21251) **IC-processed micro-motors: design, technology, and testing.** Tai, Yu-Chong (Berkeley Sensor and Actuator Center, CA (USA)); Tan, Long-Sheng; Muller, R.S. Lawrence Livermore National Lab., CA (USA). 30 Sep 1988. 8p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. Order Number DE90003929. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Micro-motors having rotors with diameters between 60 and 120 μm have been fabricated and driven electrostatically to continuous rotation. These motors were built using processes derived from IC micro-circuit fabrication techniques. Initial tests on the motors show that friction plays a dominant role in their dynamic behavior. Observed rotational speeds have thus far been limited to several hundred rpm which is a small fraction of what should be achievable if only natural frequency were to limit the response. Experimental starting voltages are at least an order-of-magnitude larger than had been expected (60 volts at minimum and above 100 V for some structures). Observations of asynchronous as well as synchronous rotation between the driving fields and the rotors can be explained in terms of the torque/rotor-angle characteristics for the motors. 6 refs., 9 figs.

8207 **Microwave fel interactions in MTX.** Thomassen, K.I. (Lawrence Livermore National Lab. (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract W-7405-ENG-48. (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 2A5.

The Microwave Tokamak Experiment (MTX) will use an FEL to amplify 250 GHz pulses from a second harmonic gyrotron oscillator to peak powers of 8-10 GW. Average powers of up to 2MW are expected at the 5 kHz repetition rate for which the FEL was designed. These intense microwave pulses raise interesting physics questions that will be addressed experimentally. Non-linear interactions governing both propagation and absorption phenomena have been analyzed with the expectation of full absorption of the power at high densities. In addition to the program of heating physics and the demonstration of FEL technology in MTX, we are exploring other new and potentially attractive ideas for current drive based on nonlinear phenomena that require the unique capability of the FEL. These include the in-situ generation of a plasma wave by a three-wave process, and the stochastic acceleration of electrons to high energies, which makes the current drive process efficient. The beat-wave process requires a second, lower power, FEL, while the stochastic process relies on achieving a very intense rf magnetic field to change the particle orbit behavior from regular to stochastic. Here, the authors describe these ideas and possible experiments in MTX to test them.

8208 **Investigation of an electron beam at long pulse widths for pumping lasers.** Sweeney, M.A. (Sandia National Lab. (US)); Patterson, E.L.; Samlin, G.E. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract AC04-76DP00789. (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4D3.

The HAWK facility has been constructed to investigate electron-beam-excited laser systems at pulse widths up to 1 ms and pump rates of $\leq$1 kW/cc^2. An electrostatic accelerator generates the 1-MeV, 0.1 to 1.5-A electron beam. The beam pulse width can be varied from 30 μs to 1 ms. The electron beam propagates through three vast valves that separate the 10^{-8} torr accelerator region, the 2-m-long vacuum isolation section, the 0.4-m-long buffer section, and the 0.6-m-long laser cell. The purpose of the buffer section is to prevent significant loss of the lasing gas during the electron-beam pump interval. An axial magnetic field reduces electron deposition in

the steel cavity walls surrounding the gas-filled buffer and laser sections. The deposition will be determined by comparing the measured data from a totally-stopping graphite calorimeter with radial and axial deposition profiles obtained with the 3-D Monte Carlo electron/photon transport code ACCEPTM. In designing experiments to be conducted on the facility ACCEPTM is being used to predict the radial and axial power deposition. The HAWK facility is described and the energy deposition for various configurations of the facility is presented.

8209 **Soft x-ray laser optics.** London, R.A. (Univ. of California, Lawrence Livermore National Lab. (US)); Ceglio, N.M.; Gaines, D.P. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract W-7405-ENG-48. (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5A1-2.

The optics of exploding foil soft x-ray lasers is discussed, including both refraction within the lasing plasma and reflection by multi-layer mirrors placed beyond the plasma. The effect of refraction on amplification and on the angular beam pattern for single pass amplifiers is described. The effect of refractive propagation on the performance of multi-pass cavities is also discussed. Within the plasma, refraction due to electron density gradients tends to direct the x rays out of high density regions. This usually has the undesirable effect of shortening the distance that the x rays stay within the plasma, thereby limiting the amount of amplification. A quantitative analysis of the propagation and amplification in an exploding foil x-ray laser is presented. It is found that refraction introduces a loss term to the laser amplification. Multi-layer mirrors have been used to increase the efficiency and quality of x-ray lasers by setting up two-pass or multi-pass amplifier cavities. The theoretical considerations impacting the curvature and placement of mirrors is discussed. The analysis of time resolved spectral data from experiments using normal incidence multi-layer mirrors is also discussed, in the context of gain and refraction models.

8210 **Optical distortions in zigzag slab amplifiers.** Summers, M.A. (Lawrence Livermore National Lab., CA (USA)); Trenholme, J.B.; Gelinas, R.J.; Doss, S.K.; Boyd, R.D.; Swift, C.D. pp. 443 of OSA conference on lasers and electro-optics (1989 Technical Digest series). Optical Society of America, Washington, DC (1989). (CONF-890423–: CLEO '89: conference on lasers and electro optics, Baltimore, MD (USA), 24-28 Apr 1989).

Technical Paper WM1.

Zigzag slab lasers operating at hundreds of watts of average power in the free-running mode at the fundamental wavelength have been reported. However, near diffraction limited beam quality at full operating power with the necessary temporal control for frequency conversion or Raman shifting remains to be demonstrated. At the Lawrence Livermore National laboratory, a 4-yr technology development program to demonstrate the potential of high average power solid states lasers has produced new laser materials and laser components and validated design models needed to demonstrate near diffraction limited beam quality and high peak power. Their zigzag slab amplifier design methodology is described and compared with measured amplifier performance. The sources of wavefront distortion and depoloarization in solid state zigzag slab laser amplifiers are described. The relative contributions of surface deformations and refractive index changes with temperature and stress are quantified for several interesting amplifier designs. Using validated numerical simulation capability, the authors developed a design methodology for zigzag slab amplifiers which will produce near diffraction limited performance under thermal load.

8211 **Time-resolved fluorescence and gain studies in discharge devices on the C-A transition of XeF.** Sze, R.C. (Los Alamos National Lab., NM (USA)); Sakai, T.; Sentis, M.; Vannini, M.; Maloney, M.; Bigio, I. pp. 443 of OSA conference on lasers and electro-optics (1989 Technical Digest series). Optical Society of America, Washington, DC (1989). (CONF-890423–: CLEO '89: conference on lasers and electro optics, Baltimore, MD (USA), 24-28 Apr 1989).

Technical Paper THA1.

The authors have undertaken extensive time-resolved fluorescence and gain measurements in a number of avalanche discharge devices preionized by VUV arcs under a variety of power deposition levels in an effort to determine the best approach toward development of an energetic tunable blue-green laser using the C-A transition of XeF. The effect of the krypton additive, which greatly improved output lasing in electron-beam-pumped systems, as well as the use of NF_3 and F_2 as halogen donors has been studied. Lasing in the blue-green in present devices is near threshold (a few microjoules) when configured as an oscillator. The essential question is how to develop a system where laser threshold can be reached in a short enough time so that there is still sufficient gain and sufficient time in the discharge to extract reasonable energies. The issue of whether to build a high power deposition and short pulse device with short cavity length or a more modest power deposition device with long stable discharge times is what the authors seek to address in these studies. Data have been obtained for helium, neon, and argon buffers at various buffer pressures. Typical data are shown.

8212 **Precision transfer function measurements of integrated optical modulators.** Lowry, M. (Lawrence Livermore National Lab., CA (USA)); Lancaster, G.; Peterson, R.T.; McWright, G.; Nelson, D.; Kidd, B. pp. 262 of Optoelectronic materials, devices, packaging, and interconnects II. McWright, G.M.; Wojtunik, H.J SPIE Society of Photo-Optical Instrumentation Engineers, Bellingham, WA (1988). (CONF-8809111–: Optoelectronic materials, devices, packaging, and interconnects II, Boston, MA (USA), 6-10 Sep 1988).

The authors present transfer function (TF) data from a 2x2 switch modulator. The data was obtained using an in-house designed and built automated measurement system that uses pulsed optical illumination at 840nm and pulsed electrical modulation input, to simulate our actual operating conditions for the device. The precision of the TF system electronics is found to be better than 1% over most of the measurement range and approaching 0.1% at the midrange of the signals. The reproducibility of the transfer functions themselves was found to be better than 2.0%. The effects of photorefractive damage on the device transfer function were studied. For optical doses of approximately 12 mJ (device output) at 840 nm the photorefractively induced changes in the TF were less than 10%. The effects of temperature on the transfer function were studied over a temperature range of 23C to 45C and found to be quite significant for one of three devices measured. For two others the temperature effects were nearly negligible.

8213 **One-kilowatt average power KD*P second harmonic generator.** Norton, M. (Lawrence Livermore National Lab., CA (USA)); Eimerl, D.; Velsko, S.; Ebbers, C. pp. 443 of OSA conference on lasers and electro-optics (1989 Technical Digest series). Optical Society of America, Washington, DC (1989). (CONF-890423–: CLEO '89: conference on lasers and electro optics, Baltimore, MD (USA), 24-28 Apr 1989).

Technical Paper FK5.

Frequency conversion of kilowatt class slab lasers requires careful management of the thermal gradients produced in the doubling crystal as a result of optical absorption. There are several ways to configure the doubler to accomplish this, but the architecture most suited to the output of kilowatt class slab lasers is a transverse gradient design. The authors have measured relevant materials parameters for KD*P, lithium iodate, and d-LAP, and constructed a prototype KD*P doubler and investigated its behavior under thermal load. They also measured by a direct method the temperature sensitivities for these materials: lithium iodate, KD*P, and d-LAP. They found that direct measurement is apparently the only way to determine it accurately. The authors have designed and constructed a prototype KD*P doubler for use with a slab laser operating up to 1 kW and a 20-Hz rep rate with good beam quality (<10X diffraction-limited). The aspect ratio of the beam (height/width) is 20. Calculations indicate that this doubler will have >50% conversion efficiency up to ~1-kW average power input and is, therefore, suitable for applications requiring 500 W of 532-nm light. It is an alternating-Z transverse gradient design. Tests on this prototype are described.

8214 **Ultrahigh-intensity KrF laser system.** Luk, T.S. (Laboratory for Atomic, Molecular, and Radiation Physics, Department of

Physics, University of Illinois at Chicago, P.O. Box 4348, Chicago, Illinois 60680 (US)); McPherson, A.; Gibson, G.; Boyer, K.; Rhodes, C. *Optics Letters (USA),* 14(20): 1113-1115 (15 Oct 1989).

The operational characteristics of an ultrahigh-intensity subpicosecond large-aperture KrF laser system are described. Measurements show the achievement of a focal spot diameter of less than 1.7 μm. Combined with measurements of the pulse width and pulse energy, this yields an average intensity of $\sim 2 \times 10^{19}$ W/cm^2, a value corresponding to a peak electric field of ~ 24 (e/a_0^2). Light sources of this nature will find application in a broad range of studies of the nonlinear properties of matter in the strong-field regime.

8215 Widely tunable single-longitudinal-mode pulsed dye laser. Raymond, T.D. (Sandia National Laboratories, Albuquerque, New Mexico 87185-5800 (US)); Esherick, P.; Smith, A. *Optics Letters (USA),* 14(20): 1116-1118 (15 Oct 1989). DOE Contract AC04-76DP00789.

We have developed a simple cavity-length-stabilization method appropriate for single-longitudinal-mode pulsed lasers that use grazing-incidence gratings. Our technique relies on the detection of a minute ({0.5-mrad) angular variation in the output beam direction caused by a detuning between the cavity-mode frequency and the center frequency of the grating passband. In a prototype system implementing this stabilization scheme we have generated single-longitudinal-mode scans of up to 290 cm^{-1}.

8216 Anomalous-dispersion phase-matched second-harmonic generation. Cahill, P.A. (Sandia National Laboratories, Division 1811, P.O. Box 5800, Albuquerque, New Mexico 87185 (US)); Singer, K.D.; King, L.A. *Optics Letters (USA),* 14(20): 1137-1139 (15 Oct 1989). DOE Contract AC04-76DP00789.

We have demonstrated anomalous-dispersion phase-matched second-harmonic generation, using electric-field-induced second-harmonic generation in a liquid solution of Foron Brilliant Blue S-R (FBB). This dye has a sharp absorption maximum near 620 nm and a deep absorption minimum near 450 nm. The microscopic hyperpolarizability (β) of FBB was measured at 1.58 and 0.954 μm and was found to be 163×10^{-30} and -118×10^{-30} cm^5/esu, respectively. The change in sign of β and the observation that β_0, a frequency-independent measure of hyperpolarizability, is the same at both frequencies demonstrate the validity of the two-state model of the second-order hyperpolarizability.

8217 Index-of-refraction change in optically pumped solid-state laser materials. Powell, R.C. (Lawrence Livermore National Laboratory, University of California, P.O. Box 5508, Livermore, California 94550 (US)); Payne, S.A.; Chase, L.L.; Wilke, G.;. *Optics Letters (USA),* 14(21): 1204-1206 (1 Nov 1989). DOE Contract W-7405-ENG-48.

Degenerate four-wave mixing measurements were made on several Nd^{3+}-doped laser materials by resonantly pumping the Nd^{3+} ions. The dominant contribution to the signal under these conditions is associated with the difference in polarizabilities of the Nd^{3+} ions in the metastable state versus the ground state. Absolute measurements of the signal strengths imply a laser-induced polarizability change of the order of 0.01–0.05 A^3. The results indicate that, for the case of a single-shot laser amplifier system, the beam distrotion induced by this population-induced change in the refractive index is comparable with the distortion arising from thermal effects.

8218 Efficient anti-Stokes Raman conversion in collimated beams. Reiser, C. (Sandia National Laboratories, Albuquerque, New Mexico 87185 (US)); Raymond, T.D.; Michie, R.B.; Hickman, A.P. *Journal of the Optical Society of America B: Optical Physics (USA),* 6(10): 1859-1869 (Oct 1989). DOE Contract AC04-76DP00789.

We have demonstrated 10% energy-conversion efficiency of 0.5-nsec FWHM laser pulses at 248 to 225 nm by an anti-Stokes process in hydrogen, using collimated (unfocused) laser beams. To accomplish this, we simultaneously seeded the Raman cell with a Stokes pulse that was 2–6% as intense as the pump at the phase-matching angle with respect to the pump beam axis. Under these conditions, a fully transient plane-wave calculation suggests that 44% energy-conversion efficiency is possible. Phase-front imperfections on the pump and Stokes beams are thought to limit the observed conversion efficiency. We present a simple model describing the effect of phase distortion on anti-Stokes production that agrees with our observations. Experimentally observed dynamic effects are in good agreement with theoretical predictions.

8219 Wiggler focused relativistic sheet beam propagation in a planar free-electron laser configuration. Radack, D.J. (Laboratory for Plasma Research, University of Maryland, College Park, Maryland 20742-3511 (US)); Booske, J.H.; Carmel, Y.; Destler, W.W.;. *Applied Physics Letters (USA),* 55(20): 2069-2071 (13 Nov 1989).

The propagation of a relativistic sheet electron beam through a spatially periodic magnetic field (wiggler) has been studied experimentally. The wiggler serves two purposes; it provides beam focusing as well as the magnetostatic pump for the free-electron laser (FEL) interaction. Experiments conducted to study sheet beam generation and propagation in a short-period (1 cm) planar wiggler are presented. A 500 keV, 7 A sheet electron beam was propagated through a 3.2 mm waveguide with negligible losses due to intercepted current. In addition, the first observation of wiggler-induced radiation was obtained from the sheet beam FEL in a short-period wiggler oscillator configuration.

8220 Plasma-implosion-driven, photoionization-pumped, soft x-ray laser targets. Hussey, T.W. (Sandia National Laboratories, Division 1261, Albuquerque, New Mexico 87185 (US)); Matzen, M.K.; McGuire, E.J.; Dalhed, H.E. *Journal of Applied Physics (USA),* 66(9): 4112-4122 (1 Nov 1989). DOE Contract AC04-76DP00789.

Designs are proposed, based on a series of one-dimensional calculations, for layered, hollow cylindrical targets to be placed on the axis of an imploding, hollow Z-pinch plasma that can create the approximate plasma conditions, as well as radiation spectrum, for a photoionization pumped, Ne-like recombination laser. The lasant must reach the Ne-like state and be at the appropriate density at the same time that the photoionizing pump radiation is present, placing severe constraints on designs for such targets. Target designs are further constrained by the fact that the $3s$-$2p$ resonance line, which depopulates the lower lasing state, must not be highly trapped and by the fact that the upper lasing state must not be collisionally depopulated. We find that hollow, cylindrical targets consisting of a few-micron-thick CH strongback, coated on the inside with a thin layer of Ni lasant and on the outside with an Al converter layer, can be optimized to achieve appropriate conditions for lasing and modest levels of gain.

8221 Resonantly photopumped Ni-like Er x-ray laser. Nilsen, J. (Lawrence Livermore National Laboratory, Livermore, California 94550 (US));. *Physical Review [Section] A: General Physics (USA),* 40(9): 5440-5443 (1 Nov 1989). DOE Contract W-7405-ENG-48.

This paper presents a laboratory x-ray laser that lases on several $4d \rightarrow 4p$ transitions ranging from 54 to 89 A in nickel-like erbium (Z=68) and that is resonantly photopumped by the $2p_{1/2} \rightarrow 1s_{1/2}$ emission line, Lyman-α, in hydrogenlike aluminum. The Al-Er scheme has a tremendous advantage in that it enhances the gain of laser lines that would be expected to lase from collisional excitations and recombination processes; therefore it should be much easier to observe the photopumping process, as it will increase an already finite exponential gain. The resonant photopumping process is also shown to create gain on one additional laser line that has not previously appeared in the Ni-like spectra. Calculations of the gain of these laser transitions in steady-state equilibrium plasmas are presented.

43 PARTICLE ACCELERATORS

4301 Design, Development, and Operation

Refer also to citation(s) 7044, 8862, 8884, 8888, 8894, 8896, 8897, 8898, 8899, 8960, 8965, 8971, 8975, 8985

8222 (BNL–43439) **SDRC I-DEAS and RHIC (Relativistic Heavy Ion Collider).** Goggin, C.M. Brookhaven National Lab., Upton, NY (USA). [1989]. 12p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-8910322–1: IDEAS/CAEDS users conference, Cincinnati, OH (USA), 3-5 Oct

1989). Order Number DE90003627. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

In August 1984, Brookhaven National Laboratory submitted a proposal to the Department of Energy (DOE) for the construction of a Relativistic Heavy Ion Collider (RHIC). Since then funding has continued for the detailed design of RHIC. The hardware for RHIC consists of two concentric rings of superconducting magnets in a 2.4 mile circumference with six intersections. Bunches of ions will travel in opposite directions in each of the two rings and eventually collide head on at one of the six intersections. The hardware design involves complicated facilities for liquid helium cryogens, cryostat design, and pipe systems. The greatest challenge however is the ion beam position relative to the geometric center of the rings. There are three hundred and seventy-two dipole magnets that are ten meters long and weigh 4300 Kg (4.5 tons) each. Each dipole must be positioned in the ring to $\pm$ 0.5 mm. In addition, there are four hundred and ninety-two quadrupole magnets that must be positioned to $\pm$ 0.1 mm which is a total position error. This total position error includes all the surveying and part tolerance. To accomplish this task requires detailed planning and design of the cryostats which contain each magnet and the tunnel assembly throughout the 2.4 mile circumference. The IDEAS' software package provides a way to analyze this large scale problem. 11 figs.

8223 (JINR-D–1-13-88-172, pp. 85-98) **Experiments with high energy nuclear beams at Brookhaven: from AGS to RHIC.** Ludlam, T.W. (Brookhaven National Lab., Upton, NY (USA)). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252– : International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

A brief description of experiments with ions accelerated in the AGS and the plans for the heavy ion beams in the near future at the AGS BoosterSynchrotron being under construction is presented. Status of the RHIC relativistic heavy ion collider project is shown. The basic parameters of the RHIC facility are illustrated. The total energy of accelerated ions with mass A=200 will attain 100 GeV/nucleon. Acceleration of all periodic sytem elements is supposed to take place. Colliding beam energies ranging from 1.5+1.5 GeV/nucleon to 100+100 GeV/nucleon will be provided for. The collider circumference is 3833 m. 12 refs.; 8 figs.

8224 (NIKHEF-K-LINO–138) **Progress report energy economization MEA: Department report.** Lely, U.P. (DHV Raadgevend Ingenieursbureau BV, Amersfoort (Netherlands)); Bruinsma, P.J.T.; Heine, E.; Koenderink, G.; Kroes, F.B.; Kuijer, L.H.; Noomen, J.G.; Spelt, J.B.; Vogel, A.G.C. NIKHEF-K-DHAV Raadgevend Ingenieursbureau Collaboration. Nationaal Inst. voor Kernfysica en Hoge-Energiefysica (NIKHEF), Amsterdam (Netherlands). Sectie K. 2 Feb 1987. 7p. (In Dutch). Order Number DE90705946. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

This report illustrates the progress of the energy-economizing project MEA. In this project measures are made which have been proposed in table 4 of the 'Program of energy-economizing measures at NIKHEF-MEA, May 1986'. The procedure of the project group involved, the development in the subprojects, the spending of the financial means, and the progress are explained respectively. 2 figs., 2 tabs.

8225 (NIKHEF-K-LINO–145) **National institute for nuclear physics and high energy physics final report project energy-economization MEA.** Lely, U.P. DHV Raadgevend Ingenieursbureau-NIKHEF-K Collaboration. DHV Raadgevend Ingenieursbureau BV, Amersfoort (Netherlands). Nov 1987. 22p. (In Dutch). Order Number DE90705945. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI.

This report is the rounding-off account of the project Energy-economizing MEA. First the development in sub-projects is outlined resulting into the actual state of affairs. Next the extent of the spendings are discussed. Finally the attained energy economizing is estimated. 4 tabs.

8226 (SAND–89-1955) **The Proto-II x-ray facility at the Simulation Technology Laboratory: A user's manual.** Zawadzkas, G.A. Sandia National Labs., Albuquerque, NM (USA). Nov 1989. 47p. Sponsored by U.S. DOE Energy Research. DOE Contract AC04-76DP00789. Order Number DE90004986. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Proto II is a nominal 8 terawatt pulsed accelerator which is available for x-ray effects testing. The purpose of this guide is to serve as a basic source of information for prospective users of Proto II. Enclosed is a discussion of the design and operation of the accelerator and a summary of x-ray environmental data. The guide also contains a description of experimental support facilities, data acquisition and analysis systems and general information for users. 4 refs., 22 figs., 5 tabs.

8227 (TRI-PP–89-39) **Computational tools for cyclotron design, commissioning, and operation.** Kost, C.J. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. May 1989. 10p. (CONF-890560–6: 12. international conference on cyclotrons and their applications, Berlin (Germany, F.R.), 8-12 May 1989). Order Number DE90004275. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

Many support systems are required in the design, commissioning, and normal operation of a modern cyclotron. Presented is an overview of the computing environment developed during these various stages at TRIUMF. The current computing environment is also discussed, with emphasis on how one can provide an integrated system which is user-friendly. 19 refs., 13 figs.

8228 (TRI-PP–89-42) **Experimental area design working group: Summary.** British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. May 1989. 7p. (CONF-890299–20: AHF accelerator design workshop, Los Alamos, NM (USA), 20-25 Feb 1989). Order Number DE90004286. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

The charge to the working group on Experimental Areas concerned a number of topics related to the optimum layout of the experimental areas, the design of secondary channels and spectrometers, the floor space required for experiments and the impact of remote handling requirements on the site layout. The talks given by the various speakers provided useful information on these topics and the subsequent discussions, in particular on the operation consideration of running an experimental program at an AHF and the method of beamline design and remote handling in the target areas resulted in a general concensus on the recommendations which are given below. 4 refs., 3 figs., 1 tab.

8229 (TRI-PP–89-71) **Kaon factories.** Craddock, M.K. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. Sep 1989. 5p. (CONF-890803–43: International conference on high energy accelerators, Tsukuba (Japan), 20-26 Aug 1989). Order Number DE90004278. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

Proposals for high intensity proton synchrotrons [typically providing 100 μA (6×10^4 p/s)] at 30 GeV have been made in Canada, Europe, Japan, the USA and the USSR. The beams would be roughly 100 times more intense than those available now and would yield equivalent increases in the fluxes of secondary particles (kaons, pions, muons, antiprotons, hyperons and neutrinos) - or cleaner beams for a smaller increase in flux. The ability to investigate rare processes on the "precision frontier" opens new avenues to fundamental questions in both particle and nuclear physics, complementary to traditional approaches via the "energy frontier." The demand for higher currents has led to novel features in many of the accelerator designs: asymmetric magnet cycles, avoidance of transition crossing, separate collector and stretcher rings, three-dimensional beam painting at injection, bucket-to-bucket beam transfer, perpendicular biassing of microwave ferrite in the rf tuners, the use of Siberian Snakes to preserve polarization, and the addition, of a pre-septum to make slow extraction >99.8% efficient. Other characteristic features include rapid cycling rates, booster stages, H^- injection, low impedance enclosures, powerful feedback systems for control of beam instabilities and beam loading, and local collimation systems for handling beam loss. This paper reviews the general features of kaon factory accelerator design and the status of the various proposals. 29 refs., 2 figs., 1 tab.

8230 (TRI-PP-89-96) **The TRIUMF Kaon factory accelerators.** Craddock, M.K. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. Nov 1989. 5p. (CONF-8906194-5: International meeting on physics at KAON, Bad Honnef (Germany, F.R.), 7-9 Jun 1989). Order Number DE90004285. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

To accelerate a 100 μA proton beam from the TRIUMF H^- cyclotron to 30 GeV a five-ring accelerator complex is proposed. Each accelerator is followed by a storage ring for time-matching — the cw cyclotron by the Accumulator, the 3 GeV 50 Hz Booster by the Collector, and the 30 GeV 10 Hz Driver by the Extender — the latter providing the slow-extracted beam for coincidence experiments. Under the current $11 million pre-construction study prototypes are being built of various components of the Booster ring — a fast-cycling dipole magnet, a dual-frequency magnet power supply, ceramic beam pipes rf cavities (both parallel and perpendicular bias versions) and an extraction kicker. In addition the lattice designs for all five rings and the shielding and remote handling requirements are being reviewed. These activities will allow construction to start in 1990. 26 refs., 5 figs.

8231 **Power balance in railgun plasmas.** Congedo, T.V. (Westinghouse R and D Center, Pittsburgh, PA (US)); Sink, D.A. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651-: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5C6.

In order to infer temperature and other key plasma parameters affecting stability and thus ultimate performance of an electromagnetic launcher, one must account for processes which either add or remove power to the plasma. An important influence on these processes is how the plasma mass is changing with time, due primarily to three effects: initial vaporization of a solid armature, ablation of mass from the walls of the bore, and loss of mass out the tail of the moving plasma. The first of these processes establishes the conducting armature in the plasma state. The latter two serve to remove energy from the plasma - either by increasing the enthalpy of the newly ablated mass as it enters the plasma, or by removing enthalpy through loss of plasma mass. The present discussion addresses the method of energy balance used in a phenomenologically modelled calculation of railgun behavior, to predict and analyze performance of railguns. Key to the calculation is the inclusion of adjustable input parameters for those quantities which, though perhaps not readily determined analytically, are either understood in an empirical fashion, or are desired to be varied to predict device performance based on intended system modifications or operating scenarios. Three equations are used to describe the plasma power balance.

4302 Beam Dynamics, Field Calculations, and Ion Optics

Refer also to citation(s) 8207, 8208, 8856, 8863, 8876, 8877, 8879, 8899, 8909, 8951

8232 (INFN-LNF-89-21(P)) **Transverse betatron tune measurements.** Serio, M. (Istituto Nazionale di Fisica Nucleare, Frascati (Italy). Lab. Nazionale di Frascati). Istituto Nazionale di Fisica Nucleare, Rome (Italy). 1989. 30p. (CONF-8810356-: 3. joint US-Cern accelerator school on particle accelerators: frontiers of particle beams, observations, diagnosis, and correction, Capri (Italy), 20-26 Oct 1988). Order Number DE90610938. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

In this paper the concept of the betatron tune and the techniques to measure it are discussed. The smooth approximation is introduced along with the terminology of betatron oscillations, phase advance and tune. Single particle and beam spectra in the presence of synchro-betatron oscillations are treated with emphasis on the consequences of sampling the beam position. After a general presentation of various kinds of beam position monitors and transverse kickers, the time domain and frequency domain analysis of the beam response to a transverse excitation are discussed and several methods and applications of the tune measurements are listed. 26 refs.

8233 (INFN-LNF-89-035(P)) **Wake field measurements.** Palumbo, L. (Istituto Nazionale di Fisica Nucleare, Frascati (Italy). Lab. Nazionale di Frascati); Vaccaro, V.G. Istituto Nazionale di Fisica Nucleare, Rome (Italy). 1989. 44p. (CONF-8810356-: 3. joint US-Cern accelerator school on particle accelerators: frontiers of particle beams, observations, diagnosis, and correction, Capri (Italy), 20-26 Oct 1988). Order Number DE90610937. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

In this paper the concept of Wakefields and Machine Impedance are introduced. Several measurements technique of these quantities either in the laboratory before installation or from beam observation are presented. 63 refs.

8234 (TRI-PP-89-72) **Lattices for the TRIUMF KAON Factory.** Servranckx, R.V.; Wienands, U.; Craddock, M.K. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. [1989]. 6p. (CONF-890803-49: International conference on high energy accelerators, Tsukuba (Japan), 20-26 Aug 1989). Order Number DE90004279. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

Separated-function racetrack lattices have been developed for the KAON Factory accelerators that have more flexibility than the old circular lattices. The arcs of the large rings have a regular FODO structure with a superimposed six-fold symmetric modulation of the betafunction in order to raise γ_t to infinity. Straight sections with zero dispersion are provided for rf cavities and fast injection and extraction, and with controlled dispersion for H^- injection and slow extraction. For the small rings, sixfold symmetric circular lattices with high γ_t are retained. In the Accumulator lattice, a straight section with double waist and controlled η function allows for H^- injection and phase-space painting. The ion-optical properties of the lattices and the results from tracking studies are discussed. 7 refs., 6 figs.

8235 (TRI-PP-89-73) **ACCSIM: A program to simulate the accumulation of intense proton beams.** Jones, F.W. (British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility); Mackenzie, G.H.; Schoenauer, H. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. Sep 1989. 6p. (CONF-890803-48: International conference on high energy accelerators, Tsukuba (Japan), 20-26 Aug 1989). Order Number DE90004280. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

ACCSIM is a multiparticle 3-D tracking code initially written to simulate multiturn injection. It treats simultaneously, but to a certain degree of approximation, transverse and longitudinal space charge forces, lattice perturbations simulated by thin multipoles, and energy loss, Coulomb and nuclear scattering in charge exchange foils or internal targets. Output includes particle distributions in phase space and real space, loss statistics and figures of merit for the retained ensemble. The program is described in detail and examples given of its use for existing and proposed machines. 10 refs., 2 figs.

8236 (TRI-PP-89-75) **Beam pipe impedances in the TRIUMF KAON factory.** Baartman, R.; Oram, C.J. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. Sep 1989. 6p. (CONF-890803-47: International conference on high energy accelerators, Tsukuba (Japan), 20-26 Aug 1989). Order Number DE90004281. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

The standard formalism for estimating longitudinal beam pipe impedances is given. Estimates of realistically obtainable impedances are developed. We show that where the impedance is critical an impedance divided by mode number of 1–2 Ω should be the design goal for the beam pipe group. However for machine design criteria and planning purposes 5 Ω should continue to be adopted so that sufficient contingency is present in the design. 4 refs., 2 tabs.

8237 (TRI-PP-89-76) **A general theory of beam loading.** Koscielniak, S. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. Sep 1989. 6p. (CONF-890803-46: International conference on high energy accelerators, Tsukuba (Japan), 20-26 Aug 1989). Order Number DE90004282. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

A matrix formalism is developed for describing the interaction of the beam-bunch fundamental harmonic component with a

radio-frequency accelerating cavity. The amplitude and phase modulations form the components of a vector. The adoption of a matrix notation systematizes and, to some degree, automates the derivation of the characteristic polynomials which determine system stability. The method is applied to derive analogues of the Robinson criterion for complex systems including combinations of phase and radial loops, quadrupole-mode damping, and fast feed-back around the cavity. 7 refs., 4 figs.

8238 (TRI-PP–89-77) **Time domain simulations of beam-loading.** Koscielniak, S. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. Sep 1989. 6p. (CONF-890803–45: International conference on high energy accelerators, Tsukuba (Japan), 20-26 Aug 1989). Order Number DE90004283. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

We present the results of computer simulations of high current beam loading in a proton storage ring. The model integrates the differential equation for gap voltage, and iterates the difference equations for particle longitudinal motion. The effects of cavity fields on the bunch shape and of the fundamental component of the beam on the cavity are treated in a self-consistent manner. The simulation model is applied to verify the dipole-quadrupole hybrid Robinson instability criterion, which differs from the dipole-mode criterion. 8 refs., 7 figs.

8239 (TRI-PP–89-78) **Stability of hollow beams in longitudinal phase space.** Baartman, R.; Koscielniak, S. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. Sep 1989. 5p. (CONF-890803–44: International conference on high energy accelerators, Tsukuba (Japan), 20-26 Aug 1989). Order Number DE90004284. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

In synchrotrons, bunched beams which are hollow in longitudinal phase space are known to be unstable. We have also found this to be true in simulations which include only the space charge force. Mode-coupling theory does predict instability but gives thresholds which are much higher than those found from simulations. 5 refs., 4 figs.

8240 **Modelling of undulator sources.** Chapman, K. (Wisconsin Univ., Madison (USA). Dept. of Electrical and Computer Engineering); Lai, B.; Cerrina, F.; Viccaro, J. *Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors, and Associated Equipment (Netherlands)*, 283(1): 88-99 (20 Oct 1989). DOE Contract W-31-109-ENG-38.

We present a new code capable of realistically modelling the radiation from ideal undulator sources, including explicit electron emittance effects. The code has been developed as part of the SHADOW X-ray optics ray tracing program, in order to predict the performances of undulator-based optical systems. The approach is based on a simplified field distribution that allows an efficient calculation of the trajectory and of the radiation field. We show explicitly that the undulator radiation pattern is shift-invariant with respect to the electron trajectory angles, so that the emittance effects can be included without recomputing the radiation distribution. Furthermore, the time consuming computation of the undulator emission patterns is decoupled from the Monte Carlo sampling of the wavefront, leading to a very fast code. This is achieved by computing the three-dimensional source probability distribution function and by using an inversion algorithm to generate a random variate with the same distribution as the source. The physical basis of the code and the algorithm used are discussed in detail and some results presented. (orig.).

4303 Auxiliaries and Components

Refer also to citation(s) 8233, 8350, 8354, 8970, 8978, 8980

8241 (BNL–43074) **Vacuum status-display and sector-conditioning programs.** Skelly, J.; Yen, S. Brookhaven National Lab., Upton, NY (USA). [1989]. 9p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-891094–7: International conference on accelerator and large experimental physics control systems, Vancouver (Canada), 30 Oct - 3 nov 1989). Order Number DE90003967. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Two programs have been developed for observation and control of the AGS vacuum system, which include these notable features: they incorporate a graphical user interface, and they are driven by a relational database which describes the vacuum system. The vacuum system comprises some 440 devices organized into 28 vacuum sectors. The Status Display Program invites menu selection of a sector, interrogates the relational database for relevant vacuum devices, acquires live readbacks, and posts a graphical display of their status. The Sector Conditioning Program likewise invites sector selection, produces the same status display, and also implements process control logic on the sector devices to pump the sector down from atmospheric pressure to high vacuum over a period extending for several hours. As additional devices are installed in the vacuum system, the devices are likewise added to the relational database; these programs then automatically include the new devices. 2 refs., 1 fig.

8242 (BNL–43075) **A C programmer's view of a relational database.** Clifford, T.; Katz, R.; Griffiths, C. Brookhaven National Lab., Upton, NY (USA). 26 Oct 1989. 10p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-891094–6: International conference on accelerator and large experimental physics control systems, Vancouver (Canada), 30 Oct - 3 nov 1989). Order Number DE90003970. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

The AGS Distributed Control System (AGSDCS) uses a relational database (Interbase) for the storage of all data on the host system network. This includes the static data which describes the components of the accelerator complex, as well as data for application program setup and data records that are used in analysis. By creating a mapping of each elation in the database to a C record and providing general tools for relation (record) across, all the data in the database is available in a natural fashion (in structures) to all the C programs on any of the nodes of the control system. In this paper the correspondence between the Interbase elations and the C structure is detailed with examples of C typedefs and relation definitions. It is also shown how the relations can be put into memory and linked (related) together when fast access is needed by programs. 1 ref., 2 tabs.

8243 (BNL–43092) **The development of controls for pulse-to-pulse modulation at the Brookhaven AGS complex.** Barton, D.S. Brookhaven National Lab., Upton, NY (USA). [1989]. 12p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-891094–9: International conference on accelerator and large experimental physics control systems, Vancouver (Canada), 30 Oct - 3 nov 1989). Order Number DE90003953. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Operation of the AGS Complex, comprising a 200 MeV Linac, the 1.5 GeV Booster (400 MeV/amu heavy ions) which is under construction, and the AGS, requires service of multiple uses with different beam requirements. Local Linac users, Booster commissioning with protons and heavy ions, and the AGS physics program and accelerator studies must run concurrently in various combinations. A new timing system is being built which will distribute serially encoded events derived from real-time and magnetic field clocks to each accelerator. The master timing of the supercycle will be managed centrally with encoded reset events determining the assigned user for each pulse. Operational aspects of the design of this system will be described, along with the principal control system modifications necessary to implement this mode of operation. 4 refs., 3 figs.

8244 (BNL–43353) **The AGS Booster vacuum systems.** Hseuh, H.C. Brookhaven National Lab., Upton, NY (USA). 1989. 13p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-890906–7: 11. international vacuum congress and 7th international conference on solid surfaces, Cologne (Germany, F.R.), 25-29 Sep 1989). Order Number DE90003644. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The AGS Booster is a synchrotron for the acceleration of both protons and heavy ions. The design pressure of low 10^{-11} mbar is required to minimize beam loss of the partially stripped heavy ions. To remove contaminants and to reduce outgassing, the vacuum chambers and the components located in them will be chemically cleaned, vacuum fired, baked then treated with nitric oxide. The

vacuum sector will be insitu baked to a minimum of 200°C and pumped by the combination of sputter ion pumps and titanium sublimation pumps. This paper describes the design and the processing of this ultra high vacuum system, and the performance of some half-cell vacuum chambers. 9 refs., 7 figs.

8245 (JINR-D–1-13-88-172, pp. 135-137) **Wide-aperture magnetic spectrometer with face position of MWPC.** Avakyan, R.O. (Erevanskij Gosudarstvennyj Univ., Erevan (USSR)); Avetisyan, A.Eh.; Ajvazyan, R.B.; Asaturyan, R.A.; Dallakyan, K.R.; Kizogyan, O.S.; Matevosyan, Eh.M.; Sukiasyan, Yu.Z.; Taroyan, S.P. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

A pair magnetic spectrometer with automated wire chambers for studying electron and positron interactions with monocrystals at the Erevan synchrotron is described. As a working gas the argon-methane mixture with methylal vapor addition is used. Results of modelling and experiments with spectrometer are presented. 2 refs.; 6 figs.

8246 (JINR-D–1-13-88-172, pp. 185-188) **Efficiency and spatial resolution of the drift chamber with hydrogen and helium filling under 9 atm pressure.** Andreev, V.A. (AN SSSR, Leningrad (USSR). Inst. Yadernoj Fiziki); Bondar', N.F.; Kribshich, A.G.; Maleev, V.P. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Results of studying the efficiency and spatial resolution of the drift chamber located inside the target and operating in pure helium or hydrogen under up to 9 atm pressure are presented. They have shown that the chamber operation in pure hydrogen and in helium-methane mixture (4% CH_4) beginning from 4 atm pressure is reliable. The chamber operational reliability is increased when 2% of methane is added to hydrogen. The chamber spatial resolution is not worse than 120 mum. 3 refs.; 4 figs.

8247 (KIYI–88-16) **Investigation of a vacuum system of the U-240 isochronous cyclotron.** Bykov, V.I.; Glushko, A.Ya.; Olejnik, E.E.; Prokopenko, V.S.;. AN Ukrainskoj SSR, Kiev (Ukrainian SSR). Inst. Yadernykh Issledovanij. 1988. 15p. (In Russian). Order Number DE90612488. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

BF-22923.

The investigation results of intensity loss causes of accelerated heavy and H^- ions on residual gas in the accelerator chamber were given. The results are compared with the gas inleakage data, performed by the MX-7304 mass-spectrometer. It was shown that the pumping out of heavy molecules of residual gas, inleakage reduction from the source and vacuum hygiene requirement observance, decrease to a considerable degree the ion intensity losses in acceleration process. 8 refs.; 7 figs.

8248 (KIYI–88-41) **Calculation of transport channel optics of U-240 cyclotron.** Val'kov, A.E.; Kosinov, G.A.; Nemets, O.F.;. AN Ukrainskoj SSR, Kiev (Ukrainian SSR). Inst. Yadernykh Issledovanij. 1988. 14p. (In Russian). Order Number DE90612503. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

BF-19167.

Calculation methods of transport channel optics are described, used at working out of OPTICS programme. The initial approximations for variables automatically exist in the programme and the optimization of focusing fields is realized providing the production of required beam parameters at the channel outlet. The programme structure is described and the calculation results are given in the second part of the paper. 8 refs.; 1 fig.

8249 (LA-UR–89-3685) **Creating the next generation control system software.** Schultz, D.E. Los Alamos National Lab., NM (USA). [1989]. 12p. Sponsored by U.S. DOE Energy Research. DOE Contract W-7405-ENG-36. (CONF-891094–10: International conference on accelerator and large experimental physics control systems, Vancouver (Canada), 30 Oct - 3 nov 1989). Order Number DE90003391. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

A new 1980's style support package for future accelerator control systems is proposed. It provides a way to create accelerator applications software without traditional programming. Visual Interactive Applications (VIA) is designed to meet the needs of expanded accelerator complexes in a more cost effective way than past experience with procedural languages by using technology from the personal computer and artificial intelligence communities. 4 refs.

8250 (LBL–26675) **Optical data transmission at the superconducting super collider.** Leskovar, B. Lawrence Berkeley Lab., CA (USA). Feb 1989. 17p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00098. (CONF-900143–4: Nuclear science symposium, San Francisco, CA (USA), 22-26 Jan 1990). Order Number DE90003997. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Digital and analog data transmissions via fiber optics for the Superconducting Super Collider have been investigated. The state of the art of optical transmitters, low loss fiber waveguides, receivers and associated electronics components are reviewed and summarized. Emphasis is placed on the effects of the radiation environment on the performance of an optical data transmission system components. Also, the performance of candidate components of the wide band digital and analog transmission systems intended for deployment of the Superconducting Super Collider Detector is discussed. 27 refs., 15 figs.

8251 (NIKHEF-K-DIGEL–73) **Filament supply for the 500 MeV electron accelerator (MEA) klystrons: Mutad 860718.** Oostveen, K.; van Es, J.T.; Kruijer, A.H.; Verkooijen, H. Nationaal Inst. voor Kernfysica en Hoge-Energiefysica (NIKHEF), Amsterdam (Netherlands). Sectie K. 18 Jul 1986. 24p. (In Dutch). Order Number DE90705969. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI.

A power supply for the filament of the MEA klystrons is described. The supply is a 1 KW 625 Hz generator. Between the supply and the filament a high-voltage separation-transformator with rectifier is positioned. Since the filament has to be heated up gradually, the filament supply rules up in about 20 minutes. The finishing of the ruling up is signalized. Subsequently one must wait another 20 minutes before the klystron is allowed to be put on high voltage. The output voltage of the supply is adjustable from about 200 to 400 volts. The supply is protected against short-circuiting and interruption of the output. This results in switching-off of the supply and in signalizing 'too low resistance' respectively 'too high resistance'. If by an internal disturbance the desired voltage and the output voltage deviate from each other, the supply drops down and indicates the error report 'over-voltage' or 'under-voltage'. The supply can be put on 'standby' or 'on' externally. Also external protections can be connected to it, like: cooling, vacuum, etc. When one of the protections drops down, the supply will drop down and give an error report. 15 figs., 1 tab.

8252 (NIKHEF-K-DIGEL–79) **The remote control system: Department report.** Jansweijet, P.P.M. Nationaal Inst. voor Kernfysica en Hoge-Energiefysica (NIKHEF), Amsterdam (Netherlands). Sectie K. 1988. 34p. (In Dutch). Order Number DE90705968. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI.

The remote-control system is applied in order to control various signals in the car of the spectrometer at distance. The construction (hardware and software) as well as the operation of the system is described. 20 figs.

8253 (NIKHEF-K-LINO–1989-3) **High voltage pickup plate: Department report.** Sluijk, T.; Dobbe, N. Nationaal Inst. voor Kernfysica en Hoge-Energiefysica (NIKHEF), Amsterdam (Netherlands). Sectie K. 2 Mar 1989. 20p. (In Dutch). Order Number DE90705966. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI.

For the 'electron gun' of the NIKHEF electron accelerator a High Voltage Pickup Plate (HVPP) has been constructed with belonging electronics, in order to investigate the stability of the voltage of the electron gun. With the HVPP it is possible to measure the absolute

quantities of the instabilities as result of the rectifying and the pulsed load, of the ICT. 28 figs., 1 tab.

8254 (ORNL/FTR–3491) **[Trigger for the WA80 experiment]: Foreign trip report, November 8, 1989–November 20, 1989.** Young, G.R. Oak Ridge National Lab., TN (USA). 4 Dec 1989. 3p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90003979. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The traveler spent two weeks at CERN working with H.A. Gustafsson of Lund University on a reinstallation of the trigger for the WA80 experiment calibration runs in December 1989. Conversations about the experimental setup for the August 1990 heavy-ion run at CERN were had with other members of WA80 who were present. Finally, a meeting was held with Dr. Richard Sumner of Princeton/L3 about the readout boards for the L3 BGO photon calorimeter.

8255 (SLAC-PUB–5127) **B-Factory Final Focus System using superconducting quadrupoles.** Ash, W.W. Stanford Linear Accelerator Center, Menlo Park, CA (USA). Oct 1989. 6p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00515. (CONF-8909233–2: Workshop on towards establishing b factory, Syracuse, NY (USA), 6-9 Sep 1989). Order Number DE90004432. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Experience with the superconducting final focus quadrupoles for the SLAC Linear Collider can be applied to a B-Factory built into the existing CESR tunnel. Such a system appears to accommodate detector and machine requirements. 4 figs., 2 tabs.

8256 (TRI-PP–89-35) **Status of the TRIUMF optically pumped polarized H^- ion source.** Buchmann, L.; Levy, C.D.P.; McDonald, M.; Ruegg, R.; Schmor, P.W. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. May 1989. 4p. (CONF-890560–10: 12. international conference on cyclotrons and their applications, Berlin (Germany, F.R.), 8-12 May 1989). Order Number DE90004271. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

The TRIUMF optically pumped polarized H^- ion source has been installed in a 300 keV high voltage platform connected by a 45 m beam transport line to the cyclotron. Several different extraction electrode systems have been tested in the electron cyclotron resonance (ECR) ion source generating the initial proton beam. Beam transport calculations for the initial section of the source demonstrate that the beam transport depends strongly on the degree of space charge compensation. H^- currents of up to 8 μA at a neutralizer Na thickness of 5×10^{13} atoms cm^{-2} have been transported into the 300 keV beam line. A polarized H^- beam has been accelerated in the cyclotron and a proton polarization of up to 50% has been achieved. The installation of a superconducting solenoid for further improving the source performance is planned for this summer. 13 refs., 4 figs.

8257 (TRI-PP–89-36) **Status of the H^- extraction program at TRIUMF.** Zach, M.; Laxdal, R.E.; Dutto, G.; Fong, K.; Mackenzie, G.H.; Pearson, J.B.; Stanford, G. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. May 1989. 4p. (CONF-890560–9: 12. international conference on cyclotrons and their applications, Berlin (Germany, F.R.), 8-12 May 1989). Order Number DE90004272. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

The principle of utilizing the $\nu_r = 3/2$ resonance for efficient direct extraction of 100 μA of H^- ions at 450 MeV from the TRIUMF cyclotron has been previously demonstrated. The initiation of the KAON Factory Project Definition Study at TRIUMF moves the emphasis of the H^- extraction effort from the design of components compatible with short beam tests to equipment suitable for the final extraction configuration and from beam dynamics studies to engineering studies. To this end a reference extraction design has been chosen and will be described. Designs for the magnetic channels, both air core and iron compensated, ranging in strength from 0.1 T to 0.45 T, are progressing. Engineering constraints complicating the implementation of the reference design will be discussed. 8 refs., 5 figs., 1 tab.

8258 (TRI-PP–89-37) **Reduction of multipactoring effects in the TRIUMF cyclotron.** Pacak, V.; Dohan, D.; Fong, K.; Worsham, R.; Dutto, G. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. May 1989. 3p. (CONF-890560–8: 12. international conference on cyclotrons and their applications, Berlin (Germany, F.R.), 8-12 May 1989). Order Number DE90004273. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

The reduction of rf leakage into the accelerating chamber has been one of the main development tasks at TRIUMF for the past few years. Rf leakage seriously limits the use and operation of diagnostic devices and is the driving force behind a resonant multipactoring discharge that occurs in the beam space. This in turn causes many problems in performance and reliability of the whole rf system. Two major problems were: the excessive heating of the mechanical dee-support structures that warps individual resonator segments, instabilities in resonant frequency caused by erratic behaviour of the multipactoring discharge. By improving the rf gap alignment, and by adjusting the distances between dees and ground panels to compensate for electrical asymmetries, a leakage reduction of 20 dB was achieved, bringing the maximum operating temperature on the resonator strongbacks down from $\lesssim$150°C to $\lesssim$80°C. Also the signal-to-noise ratio on various probes was greatly improved, and multipactoring frequency shifts were practically eliminated. 5 refs., 2 figs.

8259 (TRI-PP–89-38) **Aspects of phase space dynamics in spiral inflectors.** Balden, R.J.; Kleeven, W.; Milinkovic, L.S.; Milton, B.F.; Pearson, J.B. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. May 1989. 4p. (CONF-890560–7: 12. international conference on cyclotrons and their applications, Berlin (Germany, F.R.), 8-12 May 1989). Order Number DE90004274. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

The equations of motion for paraxial rays in a pseudo cylindrical electrostatic inflector with tilt have been known for some time. Unfortunately the origin of the various components of the electric field expansion are more poorly documented. In this paper we present a physical interpretation for each element of the electric field and then discuss how the resulting field expansion might be implemented in a FORTRAN program that tracks particles in a general magnetic field. Results from such a program are then used together with an acceptance calculation program, to study the question of inflector acceptance as a function of several inflector parameters. 10 refs., 2 figs.

8260 (TRI-PP–89-40) **Injection into a high-intensity synchrotron from a cyclotron.** Mackenzie, G.B. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. May 1989. 4p. (CONF-890560–4: 12. international conference on cyclotrons and their applications, Berlin (Germany, F.R.), 8-12 May 1989). Order Number DE90004276. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI; GPO Dep.

The first stages of the proposed 30 GeV, 100 μA TRIUMF KAON factory consist of a 0.45 GeV Accumulator ring injecting into a 3 GeV 50 Hz Booster synchrotron. The Accumulator is filled with 1.25×10^{13} protons over ~15 ms by charge exchange injection of H^- ions from the TRIUMF cyclotron. The manipulation of injection parameters to produce stable particle distributions and to control beam loss will be discussed together with features of the beam transport system which decouples and matches the cyclotron and ring. The recently funded $11M KAON Factory pre-construction Engineering Design and Impact Study will be described. 10 refs., 6 figs.

8261 (TRI-PP–89-44) **Racetrack lattices for the TRIUMF KAON Factory.** Servranckx, R.V. (British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility); Wienands, U.; Craddock, M.K.; Rees, G.H. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. May 1989. 4p. (CONF-890299–19: AHF accelerator design workshop, Los Alamos, NM (USA), 20-25 Feb 1989). Order Number DE90004287. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

Separated-function racetrack lattices have been developed for the KAON Factory accelerators that have more flexibility than the old circular lattices. The arcs of the large rings have a regular FODO structure with a superimposed six-fold symmetric modulation of the betafunction in order to raise γ_t to infinity. In the small rings, γ_t is

kept high enough by choosing a sufficiently large phase advance in the arcs. Straight sections with zero dispersion are provided for rf cavities and fast injection and extraction, and with controlled dispersion for H^- injection and slow extraction. The ion-optical properties of the lattices and the results from tracking studies are discussed. 4 refs., 8 figs.

8262 **Laboratory-scale EHD and field-desorption ion sources for pulsed-power applications.** Panitz, J.A. (Sandia National Labs., Albuquerque, NM (US)); Pregenzer, A.L.; Gerber, R.A. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 1D5.

The generation of positive ions by electrohydrodynamic (EHD) and field-desorption processes provide conceptually simple ways to generate the intense Li^+ ion beams required for light ion fusion in pulsed-power accelerators such as PBFA II. Field-ion technology has been used, for the first time, to create an electrohydrodynamic (EHD) ion source with molten lithium nitrate, and to investigate the field-desorption characteristics of solid lithium fluoride under controlled laboratory conditions. Field-ion sources use a needle-like, highly curved anode to provide an electric field between 1 MV/cm and 100 MV/cm at the anode surface with A-K gap voltages ;of 1-10 kV. During operation, electron bombardment and thermal heating of the anode is negligible, or eliminated. The composition, the spatial distribution, and the divergence of the ion beam generated by each type of source under dc conditions (as well as the wetting properties of the anode surface required for EHD operation) have been documented. These results are presented as well as plans being implemented to measure the ion production time under pulsed field conditions in the nanosecond regime.

8263 **Precision nuclear targets for Drell-Yan cross section measurements at 800 GeV.** Gursky, J. (Los Alamos National Lab., NM (USA)); Baer, H.; Flick, F.; Gallegos, D. *Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors, and Associated Equipment (Netherlands)*, 282(1): 62-66 (1 Oct 1989). (CONF-8809159–: 14. world conference of the International Nuclear Target Development Society (INTDS): heavy-ion targets and related phenomena, Darmstadt (Germany, F.R.), 5-9 Sep 1988).

Targets of iron, tungsten, carbon, and calcium or areal densities 2.3-5.8 g/cm^2 were fabricated to high precision for a fixed-target experiment performed in 1987 at Fermilab to measure relative Drell-Yan cross sections. The experiment used 800-GeV protons at an intensity of $2x10^{12}$ protons per 23-s spill. Areal densities were determined to an accuracy of approximately 1 part in 10^4. The calcium targets were vacuum-encapsulated in stainless steel by electron-beam welding. (orig.).

4304 Storage Rings

Refer also to citation(s) 8354

8264 (BNL–43573) **Arc chamber deformations in small storage rings under pressure loads.** Sharma, S. Brookhaven National Lab., Upton, NY (USA). 1988. 13p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-8808141–16: 3. international conference on synchrotron radiation instrumentation, Tsukuba (Japan), 29 Aug - 2 sep 1988). Order Number DE90003962. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Bending deformations of small storage ring vacuum chambers under atmospheric pressure are described. Results from a finite element model are presented which show that bending deformations due to pressure forces on metal bellows and arc chambers can cause severe misalignments at the exit port. The deformations are shown to be larger in arc chambers of small radii. The effect of using bellows load compensators and flexible supports to reduce the deformations in an existing storage ring by an order of magnitude is evaluated by analysis and compared to actual measurements. 3 refs., 5 figs.

8265 (JINR-E–9-89-491) **Automatic control system of the PIG ion source for the U-400 cyclotron.** Kutner, V.B. (Joint Inst. for Nuclear Research, Dubna (USSR)); Subbotin, V.G.; Sukhov, A.M.; Tretyakov, Yu.P.; Fefilov, B.V.; Kasyanov, A.A.; Rybin, V.M. Moskovskij Inzhenerno-Fizicheskij Inst., Moscow (USSR). 1989. 10p. (CONF-890703–29: International conference on ion sources, Berkeley, CA (USA), 10-14 Jul 1989). Order Number DE90004315. Available from NTIS (US Sales Only), PC A02/MF A01; OSTI; Joint Institute for Nuclear Research, Publishing Department, Head Post Office, P.O. Box 79 101000, Moscow, USSR.

An automatic control system is described for the cyclotron U-400 multiply-charged ion source based on CAMAC apparatus and microprocessor controllers. The system allows the automatic tuning of the ion source to the necessary regime, including the automatic start-up of discharge, the obtaining of the necessary parameters of sputtering, the automatic search for a maximum beam current within the given discharge parameters. The system performs tuning the ion source to the quasioptimal regime for 10–15 minutes with up 5% deviation from the preset parameters. It is possible to stabilize the beam current within 3% using the automatic correction of the discharge regime. 6 refs., 4 figs.

8266 (NIKHEF-K-APS–88-03) **Apertures of ring quadrupoles and sextupoles.** Maas, R.; Wu, Y. Nationaal Inst. voor Kernfysica en Hoge-Energiefysica (NIKHEF), Amsterdam (Netherlands). Sectie K. 12 Aug 1988. 10p. Order Number DE90705949. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

In order to reach a decision about the mechanical dimensions (apertures and lengths) of the Stretcher/Storage ring quadrupoles, some considerations are presented. Since the requirements for Stretcher Mode and Storage Mode are fundamentally different, they are treated separately. 4 refs., 3 figs., 1 tab.

8267 (NIKHEF-K-APS–88-04) **Orbit correction scheme for the new ring.** Wu, Y.Y. Nationaal Inst. voor Kernfysica en Hoge-Energiefysica (NIKHEF), Amsterdam (Netherlands). Sectie K. Aug 1988. 9p. Order Number DE90705948. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

In a former report ideal alignment and setting of magnetic elements were assumed in the optical design of the Amsterdam Pulse Stretcher. In real life errors will be present: misalignments, incorrect filed settings, magnetic field, inhomogeneities, etc. These errors can cause unacceptably large deviation of the closed orbit. The Stretcher ring has a four-fold symmetric structure. Every quadrant includes two matching sections and a curved section: the latter consists of four cells. The locations of orbit correctors and position monitors in curve and straight are defined. The orbit correction scheme is arranged systematically in the ring – in each quadrant the arrangement of orbit correctors and position monitors is the same. This report presents an orbit correction scheme that reduces the closed orbit deviation by at least an order of magnitude. The scheme has been verified both for the stretcher mode and storage mode operation of the ring. 4 refs., 2 figs., 2 tabs.

8268 (NIKHEF-K-DIGEL–78) **Bitbus data transport by galvanic interface: Department report.** Jansweijer, P.P.M.; Hogenbirk, J.J. Nationaal Inst. voor Kernfysica en Hoge-Energiefysica (NIKHEF), Amsterdam (Netherlands). Sectie K. 1988. 21p. (In Dutch). Order Number DE90705947. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI.

For a bitbus system in a raw environment galvanic interfaces are necessary. This report offers various possibilities for implementing such a galvanic interface. One of the possibilities is described in detail. Along the objects to be controlled an apart ringline runs in behalf of the bitbus. The various bitbus components which have been mounted near these objects, are coupled to this ringline via opto-couplers. 6 refs., 9 figs.

8269 (NIKHEF-K-IT–89-01) **A study of the beam-target interactions in a storage ring.** Kalantar-Nayestanaki, N. Nationaal Inst. voor Kernfysica en Hoge-Energiefysica (NIKHEF), Amsterdam (Netherlands). Sectie K. Jan 1989. 20p. Order Number DE90705967. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI.

Two sets of calculations have been performed for the proposed ring at NIKHEF-K. The first set is concerned with the emittance growth of the beam in the presence of an internal target. All calculations were done with a Hydrogen target. The energy range of the electron beam is 300–900 MeV. Simulations were performed for this investigation. For all calculations, 1000 particles traversed the target 1,000,000 times and the emittance growth rate was determined. The largest hydrogen target density that can be tolerated is 10^{17} atoms/cm^2. For lower energies, this limit is much smaller. In the second set of calculations electron beam loss mechanisms were investigated. It is shown that processes such as bremsstrahlung, single scattering, multiple scattering and Moeller scattering all contribute to the loss of electrons in the beam. The bremsstrahlung lifetime becomes smaller for heavier elements. Single scattering was examined using single nuclear models to obtain the number of electrons scattering outside some aperture. Electrons are also lost due to small angle scatterings in the target. To investigate this effect, the standard multiple scattering theory was utilized. Finally, the largest transverse contribution was observed to be from Moeller scattering in the target. For larger energies, due to small damp times, multiple scattering can be totally ignored. Combining all these effects and noting that the emittance growth limits us to densities less than 10^{17} atoms/cm^2 for E_0 = 900 MeV, a lifetime is obtained of about 30 seconds for the beam. This means that after 30 seconds, about 63% of the electrons are lost and the beam has to be dumped. For lower densities, the lifetime is larger than 1 minute so that lower energies can also be accommodated. Therefore, with the design parameters of the NIKHEF-K ring, long storage times are feasible with luminosities of up to 10^{35} cm^{-2}s^{-1}.

8270 (NIKHEF-K-MTG–1989-1) **Airpads: Department report.** Pouw, P. Nationaal Inst. voor Kernfysica en Hoge-Energiefysica (NIKHEF), Amsterdam (Netherlands). Sectie K. 11 Feb 1989. 12p. (In Dutch). Order Number DE90705944. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI.

In this report the results are presented of experiments with airpads for displacing the Energy Spectrum Compressor magnets of the NIKHEF Update Storage Ring. 8 figs.

8271 (TRI-PP–89-47) **Low frequency processinng for PSR beam position monitors.** Rawnsley, W.R.; Mackenzie, G.H. British Columbia Univ., Vancouver, BC (Canada). TRIUMF Facility. May 1989. 7p. (CONF-890299–18: AHF accelerator design workshop, Los Alamos, NM (USA), 20-25 Feb 1989). Order Number DE90004288. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

The beam is injected into the Proton Storage Ring (PSR) as a train of sub-nanosecond pulses at the linac frequency of 201.25 MHz. This frequency component is sensed by 20 pairs of 200 MHz stripline beam position monitors and multiplexed to an autocorrelation position processor. The analog position information is sampled, digitized and stored under the control of timing circuits. Beam position histograms from sets of monitors are displayed in the control room. Measurements show that the amplitude of the 200 MHz component is constant during the fill indicating that the strength of the most recently injected beam does not drift during the fill. This structure begins to disappear 20 to 30 turns after a particular batch of beam has been injected. The low frequency components, however, persist and might be used to measure the position of the accumulated beam. We report calculations and experimental results for some low frequency processing systems. 4 refs., 20 figs.

44 INSTRUMENTATION

4401 Radiation Instrumentation

Refer also to citation(s) 7510, 7881, 7897, 8104, 8249, 8614, 8615, 8616, 8618, 8619, 8753, 8796

8272 (ANL-HEP-CP–89-91) **Surface underground coincidences at the Soudan mine.** DasGupta, U. (Minnesota Univ., Minneapolis, MN (USA)); Ambats, I.; Ayres, D.; Balka, L.; Barrett, W.L.; Dawson, J.; Fields, T.; Goodman, M.C.; Hill, N.; Jankowski, D.J.; Lopez, F.; May, E.; Price, L.; Schlereth, J.; Thron, J.; Border, P.; Courant, H.; DahArgonne National Lab., IL (USA). High Energy Physics Div. [1989]. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract W-31109-ENG-38. (CONF-900129–5: 21. international cosmic ray conference, Adelaide (Australia), 6-19 Jan 1990). Order Number DE90003813. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

A 37 m^2 surface array which has been operating in coincidence with the Soudan 1 underground experiment is described. A comparison is made between measured and expected underground-surface coincident events. The surface array is used to "tag" the energy of the cosmic ray primary. Distributions of event rates and multiple muon rates as a function of energy are shown. Expected rates and plans for an enhanced array and for coincidences with Soudan 2 are also discussed. 1 ref., 6 figs.

8273 (BNL–43559) **Readout techniques and radiation damage of undoped cesium iodide.** Woody, C.L. (Brookhaven National Lab., Upton, NY (USA)); Levy, P.W.; Kierstead, J.A.; Skwarnicki, T.; Sobolewski, Z.; Goldberg, M.; Horwitz, N.; Souder, P.; Anderson, D.F. Brookhaven National Lab., Upton, NY (USA). [1989]. 9p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (OG–1094;CONF-900143–5: Nuclear science symposium, San Francisco, CA (USA), 22-26 Jan 1990). Order Number DE90004149. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Several readout techniques for undoped CsI have been studied which utilize the fast scintillation component for speed, and the high photon yield for good energy resolution. Quantum yields have been measured for samples up to 30 cm in length using photomultiplier tubes, wavelength shifters, and silicon photodiodes. A study has also been made of the scintillation properties of undoped CsI. It is found that the light output and decay time of the 310 nm fast component increases and the emission spectrum shifts to longer wavelengths at lower temperatures. The effects on the optical transmission and scintillation light output due to radiation damage from ^{60}Co gamma rays has been measured for doses up to ~10^5 rad. It is found that the radiation resistance of undoped CsI is substantially higher than has been reported for thallium doped CsI. 16 refs., 11 figs., 3 tabs.

8274 (BONN-IR–88-25) **Investigations of operating parameters of the planar drift chambers at the SAPHIR detector.** Hilger, G. Bonn Univ. (Germany, F.R.). Physikalisches Inst. May 1988. 59p. (In German). Order Number DE90732388. Available from NTIS (US Sales Only), PC A04/MF A01.

The lateral planar drift chambers (PDCs) of the SAPHIR detector were subjected to intensive test measurements in the electron testing beam of the Bonn 2.5 GeV synchrotron. Different drift gas mixtures were tested and the response probability and the course of the position/drift time relation were investigated. In this context, a program package was developed which, from data of two reference drift chambers, determines the position in a chamber to be investigated with an accuracy of 75 mum. (orig./HP).

8275 (BONN-IR–88-50) **Calibration and magnetic field shielding of an aerogel Cherenkov counter at the SAPHIR detector.** Schwadorf, U. Bonn Univ. (Germany, F.R.). Physikalisches Inst. Sep 1988. 49p. (In German). Order Number DE90732389. Available from NTIS (US Sales Only), PC A03/MF A01.

It was shown under which conditions the application of an aerogel Cherenkov counters at the SAPHIR detector is possible. To this end it is necessary to shield the photomultipliers against the magnetic field for the selection of the signals. This can be achieved by mounting an iron plate of 2 cm thickness between detector coil and the photomultiplier and by additionally wrapping the first photomultiplier with a correcting coil. Furthermore an online program was tested which controls the voltage supply and the amplification of the photomultipliers. This program worked reliably in the test and was expected to reliably carry out the necessary calibration processes also during measurement. Simulations with GEANT showed that the aerogel Cherenkov counter was to have a positive detection probability for pions of at least 90%. This is made up of about 2% of misinterpreted kaons and an actual particle detection probability of 90-95%. (orig./HP).

8276 (CONF-900143–1) **Monte Carlo and experimental evaluation of BC-454 for use as a multienergy neutron detector.** McElhaney, S.A.; Bauer, M.L.; Chiles, M.M.; Emmett, M.B.; Todd, J.H. Oak Ridge National Lab., TN (USA). [1989]. 8p. Sponsored by U.S. Department of Defense. DOE Contract AC05-84OR21400. From Nuclear science symposium; San Francisco, CA (USA); 22-26 Jan 1990. Order Number DE90003066. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

A boron-substituted plastic scintillator has been evaluated for use as a multienergy neutron detector in the Navy RADIAC Development Program. Monte Carlo codes were run for a 1-in.-diam × 1-in.-long scintillator and a 2-in.-diam × 2-in.-long. Additional calculations were run with each scintillator encased in 2 in. of polyethylene moderator. Response curves for neutron sensitivity as a function of energy were plotted from these calculations. Results show a close approximation between the analytically modeled response and the response obtained from a commercially available multienergy neutron detector. The scintillator also were evaluated experimentally for comparison with Monte Carlo results. Each scintillator was coupled to a photomultiplier tube and subjected to neutron irradiation at the Oak Ridge Electric Linear Accelerator facility at Oak Ridge National Laboratory. Results indicate that the experimental configuration used was rejecting proton recoil events <1 MeV. This proton recoil cutoff energy resulted in an underrepresented intermediate energy region. 9 refs., 8 figs., 2 tabs.

8277 (DOE/ER/40039–32) **Overview of the MACRO [Monopole, Astrophysics, Cosmic Ray Observatory] detector at the Gran Sasso Laboratory.** MACRO Collaboration. Texas A and M Univ., College Station, TX (USA). Dept. of Physics. [1989]. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract AS05-81ER40039. (CONF-891260–1: International cosmic ray conference, Adelaide (Australia), 28 Dec 1989). Order Number DE90003242. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

The MACRO (Monopole, Astrophysics, Cosmic Ray Observatory) detector which is being installed at the underground Gran Sasso Laboratory (I.NGS) is described in detail. The performance of the detector's first supermodule (~800 m^2sr), which had its initial data run from February 27 to May 30, 1989, is reported. About 245,000 muon triggers were recorded during this first run. The physics results obtained are reported to this conference in papers HE 4.5-2, HE 4.5-8, HE 6.1-1, HE 7.2-10, and HE 7.2-12. In addition, results obtained in conjunction with the EASTOP detector, located on top of the Gran Sasso mountain, are reported in papers HE 4.4-3 and HE 4.4-4. 4 refs., 4 figs.

8278 (DOE/ER/40039–35) **Single muon physics with the MACRO detector.** MACRO Collaboration. Texas A and M Univ., College Station, TX (USA). Dept. of Physics. [1989]. 5p. Sponsored by U.S. DOE Energy Research. DOE Contract AS05-81ER40039. (CONF-891260–4: International cosmic ray conference, Adelaide (Australia), 28 Dec 1989). Order Number DE90003239. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

The first supermodule (12 m × 12 m × 5 m) of the MACRO detector at the Gran Sasso Laboratory has been operating since the end of February 1989. About 245,000 muon triggers have been collected in the first three months of data taking in ~1890 hours of live-time. In this paper we describe the detection features of MACRO as a muon and as a high energy muon neutrino telescope to search for high energy point sources of cosmic rays. A preliminary analysis of the collected data is presented. 10 refs., 6 figs.

8279 (FNAL-TM–1632) **Limitations to very high rate wire chambers in fixed target geometries.** Spiegel, L. Fermi National Accelerator Lab., Batavia, IL (USA). Nov 1989. 8p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH03000. Order Number DE90004998. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

The task is to explore physical limitations to the operation of wire chambers in fixed target geometries at an interaction rate of 52 MHz (chosen as it corresponds to the FNAL accelerator rf rate.) That is, to see if there are physical limitations to the operation of gaseous wire chambers at such a high operating rate. A primary proton beam energy of 800 GeV has been assumed although modest increases in the primary energy should not affect the basic conclusion as secondary multiplicity increases logarithmically with center-of-momentum energy. By sustaining a 52 MHz interaction rate it is meant that results from a given interaction are electronically isolated from preceding and subsequent rf buckets, good wire plane efficiency is maintained throughout the active region of the chamber, and the chamber operates in a stable manner throughout the course of a typical fixed target run – six months to a full year. Other working assumptions include the understanding that chamber electronics – amplifiers, discriminators, delay elements, encoders – will not suffer degradation at 52 MHz and that the intensely populated beam regions have been somehow excluded from the chambers. 7 refs., 2 figs.

8280 (JINR-D–1-13-88-172, pp. 35-44) **DELPHI detector: novel features and status.** Hilke, H.J. (European Organization for Nuclear Research, Geneva (Switzerland)). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Construction of the DELPHI detector aimed at identification of electrons, photons and hadrons in LEP storage rings is briefly described. Performances of some detector components are presented. A projection chamber is a detector of modern desing. The ring imaging Cherenkov counters provide for unique hadron identification. 2 refs.; 12 figs.

8281 (JINR-D–1-13-88-172, pp. 16-23) **Universal calorimetric detector as a the set-up for colliding beam experimets.** Vorob'ev, A.P. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

A desing of universal calorimetric detector (UCD) for colliding proton-proton beam experiments in the accelerator and storage facility is described. The UCD is to be constructed by 1996. The UCD experimental program includes both check of forecasting of the standard model (SM) of strong and weak interactions and search for effects beyond the frames of SM. The UCD is made of a central part, two edge and two external parts. All parts contain track sytems, electromagnetic and hadron calorimeters and muon spectrometers. Besides the central part includes a transition radiation detector and a superconducting solenoid. The beam point of intersection is surrounded by a system of drift chambers. Vertex detector includes a semiconductor detector and a drift chamber. 2 figs.

8282 (JINR-D–1-13-88-172, pp. 24-34) **Initial performance of TOPAZ TRC at TRISTAN.** Iwata, S. (National Lab. for High Energy Physics, Tsukuba, Ibaraki (Japan)). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

First results of experiments with the TOPAZ large-aperture spectrometer in the TRISTAN electron-positron storage ring are presented. The spectrometer structure and readout system are described. The spectrometer is 260 cm in-diameter and 300 cm long. The calibration results and main performances are presented. 11 refs.; 7 figs.; 2 tabs.

8283 (JINR-D–1-13-88-172, pp. 45-57) **CLEO II detector.** Hartill, D.L. (Cornell Univ., Ithaca, NY (USA)). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Modification of the CLEO II detector designed for identification of vector mesons and b-quarks in experiments on the Cornell

University electron storage ring is described. A high-resolution electromagnetic calorimeter based on CsI scintillation crystals with the data read-out using silicon photodiodes is the main improvement incorporated in CLEO II. A new larger-diameter superconducting solenoid aimed at increasing spatial resolusion is constructed. A new steel yoke, hadron abserber and muon counters based on plastic tubes operating in the proportional regime are also fabricated. The experiments are to begin in January 1989. 4 refs.; 3 figs.

8284 (JINR-D–1-13-88-172, pp. 58-66) **Detector KEDR proposal.** Anashin, V.V. (AN SSSR, Novosibirsk (USSR). Inst. Yadernoj Fiziki); Anashkin, Eh.V.; Aul'chenko, V.M. and others. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Status of the KEDR detector proposal designed for experiments at the VEPP-4M in the energy range up to 6 GeV is given. The experimental program includes study of b-quark physics and investigation into two-photon processes. Two detector prototypes are considered. The detector includes electromagnetic calorimeter, microvertex detector, vertex detector, central drift chamber, hadron identification system, magnetic coil, magnet yoke and transport system. 19 refs.; 3 figs.

8285 (JINR-D–1-13-88-172, pp. 67-84) **Large cylindrical drift chamber for the BES spectrometer at the BEPC collider.** Bai Jingzhi (Academia Sinica, Beijing, BJ (China). Inst. of High Energy Physics); Ma Jimao; Mao Huishum and others. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Structure and test results of large cylindrical drift chamber prototype used for measuring tracks, momentum and energy losses of charged particles at the BEPC electron-positron collider are described. The chamber consists of 10 concentric cylindrical layers each containing from 48 to 108 cells counted for a total 702 cells. 89% argon, 10% CO_2 and 1% CH_4 gas mixture is planned to be used. 7 refs.; 17 figs.; 2 tabs.

8286 (JINR-D–1-13-88-172, pp. 99-114) **Review of muon detectors and triggers at hadron colliders.** Wacker, K. (Technische Hochschule Aachen (Germany, F.R.). Lehrstuhl fuer Experimentalphysik 1A und 1. Physikalisches Inst.). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Muon detectors existing and future hadron colliders are described. Problems of high energy physics concerning colliding hadron beams are enumerated. Principle of muon detection is presented. Design of UA1, CDF and DO muon detectors is given. 14 refs.; 17 figs.

8287 (JINR-D–1-13-88-172, pp. 138-148) **Recent developments with position-sensitive gaseous detectors.** Sauli, F. (European Organization for Nuclear Research, Geneva (Switzerland)). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Position-sensitive gaseous detectors developed at CERN for colliding beam experiments are described. Modular structure of 2 m long vertex detector consisting of 48 modules with 3500 signal wires is presented. The detector test results are given. Electromagnetic calorimeter, positron chamber and the imaging chamber are described. 14 refs.; 17 figs.

8288 (JINR-D–1-13-88-172, pp. 163-171) **Research and development of time expansion chamber.** Viertel, G.M. (Eidgenoessische Technische Hochschule, Zurich (Switzerland). Lab. fuer Hochenergiephysik). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Operational experience with time expansion chamber designed for experiments at the LEP colliding beams in CERN is described. The cylindrical chamber has an inner diameter of 170 mm and the outer diameter of 930 mm, the sensitive wire length is 800 mm, the working gas mixture is CO_2 (80%) and isobutane (20%). Problems of different gas filling, data readout, stability of the chamber operation are investigated. The best spatial resolution is 50 mum. 18 refs.; 13 figs.

8289 (JINR-D–1-13-88-172, pp. 115-119) **Muon spectrometer of the tagged neutrinos facility.** Winde, M. (Joint Inst. for Nuclear Research, Dubna (USSR)); Golutvin, I.A.; Dodokhov, V.Kh. and others. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Parameters of the muon spectrometer of the tagged neutrinos facility constructed in IHEP for measuring momentum and sihn of muon charge produced in neutrino interactions are presented. Spectrometer is composed of eight magnetized disks 5 m in diameter and 25 cm thick interleaved with coordinate planes. Each disk has a winding providing for magnetic field intensity within 1.5-1.9 T. Charged particle coordinates are determined by measuring drift time in drift tubes. 80/20% argon-methane mixture is a working gas. Total tube volume is 30 m^3. Flowsheet of readout system and characteristics of drift tubes are presented. 7 figs.

8290 (JINR-D–1-13-88-172, pp. 120-124) **Muon magnetic spectrometer for the ANI experiment.** Asatiani, T.L. (Erevanskij Fizicheskij Inst., Erevan (USSR)); Ivanov, V.A.; Ter-Antonyan, S.V.; Mnatsakanyan, Eh.A. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Muon magnetic spectrometer for investigation of hadron-nuclei interactions, gamma astronomy and some astrophysical problems is described. The spectrometer is constructed in Erevan. At present erection of spectrometer yoke is being finished. To acquire trusty data on muon component of extensive air showers with 10^3-10^5 TeV energies the spectrometer area was chosen equal to 40 m^2, magnetic path length - 1.8 m, magnetic induction - 1.8 T. Assumed maximum measued pulse is $\sim$ 3 TeV/c. 4 refs.; 3 figs.

8291 (JINR-D–1-13-88-172, pp. 125-128) **IHEP drift chamber for IHEP-JINR neutrino detector.** Bozhko, N.I. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij); Borisov, A.A.; Bulgakov, N.K. and others. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium: on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

The IHEP drift chamber system for detection of charged particle tracks in the IHEP-JINR neutrino detector target is described. The system consists of 385 chambers. Each chamber 4x0.5 m in size has four signal wires with +- 0.75 mm alternating shift and two 250 mm long drift gaps. 6% CO_2-argon mixture is used in the chambers. The chamber coordinate resolution is 3.5 mm, the angular resolution is about 45 mrad. 3 refs.; 6 figs.

8292 (JINR-D–1-13-88-172, pp. 129-131) **Coordinate system of the KMD-2 detector.** Anashkin, Eh.V. (AN SSSR, Novosibirsk

(USSR). Inst. Yadernoj Fiziki); Aul'chenko, V.M.; Baru, S.E. and others. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

For realization of novel possibilities of the VEPP-2M complex the KMD-2 detector for detection of charged particles and photons is constructed. Coordinate system of the detector consists of cylindrical drift and two-layer proportional chambers installed inside superconducting solenoid with 2 T magnetic field. The prototype spatial resolution is 120 mum for perpendicular tracks and 450 mum for sloping ones (30 deg). 2 refs.; 2 figs.

8293 (JINR-D–1-13-88-172, pp. 132-134) **Large-square coordinate detector based on streamer tubes.** Aul'chenko, V.M. (Tbilisskij Gosudarstvennyj Univ., Tbilisi (USSR)); Bajbusinov, B.O.; Lel'chuk, M.Yu.; Nomerotskij, A.B.; Chegodaev, A.V.; Chilingarov, A.G. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

The KMD-2 and KEDR muon detector system for experiments at VEPP storage rings is described. The KMD-2 muon system includes two layers of streamer tubes separated by the magnet yoke iron. Each layer consists of 8 octant-units. The tubes inside the unit are seriesly connected into batches of 4 for inner units (tube diameter is 20 mm) and into batches of 8 for outer units (tube diameter is 40 mm). The total tube number constitute 656, the chammel number being 128. The KEDR muon sytem for the VEPP-4 stirage ring will consist of 5 thousands of streamer tubes 40 mm in-dameter and 4-5 m long connected into batches of 4 tubes. Flowsheet of electronic channel is presented. One time channel permits to get 12x20 mm spatial resolution at detector square of 40x20000 mm. 3 refs.; 1 fig.

8294 (JINR-D–1-13-88-172, pp. 149-162) **Limits of position resolution in an induction drift chamber due to fluctuations of ionization loss.** Walenta, A.H. (Siegen Univ. (Gesamthochschule) (Germany, F.R.)). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Limits for spatial resolution in an induction drift chamber due to fluctuations of ionization loss are analysed. Results of the Monte Carlo calculation of X-ray absorption coefficient and energy losses as well as main chamber parameters for different gases are presented. Results of calculation and measurements of particle track spatial resolution are given. 14 refs.; 15 figs.; 1 tab.

8295 (JINR-D–1-13-88-172, pp. 172-177) **Z-detector for the L3-experiment.** Deiters, K. (Akademie der Wissenschaften der DDR, Berlin-Zeuthen (German Democratic Republic). Inst. fuer Hochenergiephysik). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Description and test results of the Z-detector prototype being part of the L3 vertex detector are presented. The Z-detector consists of two cylindrical proportional chambers with cathode data readout and is designed for measurement of the charged particle Z-coordinate (in beam direction) at the entrance into electromagnetic calorimeter in experiments at the LEP storage rings. The chamber outer radius is 490 mm, the inner one is 469 mm. Ar/CO_2 (80%/20%) is a working gas. Results of efficiency and spatial resolution measurements are presented. 3 refs.; 5 figs.

8296 (JINR-D–1-13-88-172, pp. 178-184) **Outer z drift chamber for the H1-detector at HERA.** Kostka, P. (Akademie der Wissenschaften der DDR, Berlin-Zeuthen (German Democratic Republic). Inst. fuer Hochenergiephysik). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Design and test results of the z drift chamber prototype being a part of the H1 detector at the HERA storage ring are described. Parameters of 2.4 m long and 92 cm in-diameter chamber consisting of 23 rings each having 24 drift cells are presented. The chamber should be at DESY in the middle of 1989. The chamber resolution is 350 mum. 10 refs.; 4 figs.; 2 tabs.

8297 (JINR-D–1-13-88-172, pp. 189-193) **Proportional chambers with high uniform gas amplification for transition radiation detector.** Andreev, V.A. (AN SSSR, Leningrad (USSR). Inst. Yadernoj Fiziki); Gavrilov, G.E.; Krivshich, A.G.; Patrichev, S.K.; Sokol'skaya, R.P. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Measurement results of gas amplifications (GA) of proportional chambers being part of transition radiation detector are presented. The proportional chamber had 100x600 mm sensitive area with 8 mm anode-cathode gap. Anode wires were made of tungsten 25 mum in-diameter and were tightened with 2 mm spacing. Cathode planes were made of 4 mum thick aluminized mailar. The chamber was filled with Xe + 30% CH_4 mixture. Eleven structural factors influencing GA fluctuation value that is 10% were considered. 2 refs.; 6 figs.

8298 (JINR-D–1-13-88-172, pp. 194-198) **Design and fabrication of large multiwire proportional chambers.** Amaglobeli, N.S. (Tbilisskij Gosudarstvennyj Univ., Tbilisi (USSR)); Bagaturiya, Yu.Sh.; Burov, R.V.; Glonti, L.N.; Sakandelidze, R.M.; Sakhalashvili, T.M.; Chaladze, B.G. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Design and test results of large multiwire proportional chambers (MPC) are given. MPC fabrication technology is described. Bench tests of the chambers were carried out at the IHEP U-70 accelerator muon beam. Dependence of MPC efficiency on the voltage is shown. Plateau length is ~ 150 V and efficiency is 90%. Gas working mixture consists of 77% Ar + 23% CO_2 + 0.05% freon with isopropyl ether addition. The mean leakage current for 24 hours is 6-8 mum, the voltage being 3 kV. 1 ref.; 5 figs.

8299 (JINR-D–1-13-88-172, pp. 199-201) **Sector drift chamber for experiment for research of rare pion-nuclear reactions at the Moscow Meson Factory.** Kovinskij, V.I. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). Inst. Atomnoj Ehnergii); Patarakin, O.O.; Sustavov, A.F.; Shul'ginov, A.V.; Berlev, A.I.; Krasnov, V.A.; Prokhvatilov, I.V. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Cylindrical drift chamber for a multipurpose facility with position detectors in solenoidal magnetic field aimed at studying rare pion-nuclear interactions at the Moscow Meson Factory is described. The drift chamber 1000 mm long with the outer diameter of 970 mm is made of 12 separate modules. Experimental results on spatial resolution determination at the drift chamber test module in the ion beam with energy in a pulse of 600 MeV/c are presented. A flowsheet of data readout system is presented. 3 refs.; 4 figs.

8300 (JINR-D–1-13-88-172, pp. 237-239) **Study on the relativistic particle avalanche detector.** Karpenko, G.V. (Joint Inst. for

Nuclear Research, Dubna (USSR)); Krumshtejn, Z.V.; Tokmenin, V.V.; Khazins, D.M.; Khovanskij, N.N. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

To design a high-precise coordinate detector with high loading capability the relativistic particle avalanche detector (of heavy ions in particular) is studied. Stable operation of avalache detector is obtained using as a working gas argon and 0.5% isobutane mixture at the pressure of 2 atm. The efficiency on the counting response plateau is 99%. 11 refs.; 4 figs.

8301 (JINR-D–1-13-88-172, pp. 243-252) **Warm liquid calorimetry in the UA1 experiment.** Sass, J. (European Organization for Nuclear Research, Geneva (Switzerland)). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

A calorimeter for the UA1 experiment is desiged. Dielectric liquid tetramethylpentane (TMP) working at room temperature is chosen as the calorimeter working liquid. Each calorimeter module has 8 10x10 cm anodes placed inside the cell and separated by 1.25 mm drift gap. These cells together with uranium plates form a sandwich-type structure. Test results for two calorimeter prototypes are presented. Results of resolution and linearity measurements for 10-70 GeV electrons are given. The given calorimeter is shown to be worth considering for future accelerator facilities. 15 refs.; 12 figs.; 1 tab.

8302 (JINR-D–1-13-88-172, pp. 286-298) **Design of the forward RICH counter in DELPHI and results from operation of a full-scale prototype.** Beltran, P. (National Research Centre for the Physical Sciences Democritos, Athens (Greece)); Botner, O.; Dam, Ph. and others. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

For e/π/K/p particle identification in DELHI the Ring Imaging Cherenkov (RICH) counter is constructed at CERN. The detector design and test results of full-scale detector prototype with different gaseous filling are given. 7 refs.; 7 figs.; 1 tab.

8303 (JINR-D–1-13-88-172, pp. 299-308) **Analysis of Cherenkov rings measured with the final chambers of the DELHI barrel RICH.** Bloch, D. (Strasbourg-1 Univ., 67 (France). Centre de Recherches Nucleaires); Dracos, M.; Dulinski, W. and others. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Results of measuring Cherenkov radiation rings with the final chamber of the RICH detector with isobutane as a working gas are presented. Measurements were carried out at the 10 GeV/c π^- beam. The mean number of detected Cherenkov photoelectrons is 13.7+-2. Angular resolution is 3.94+-0.3 mrad. The relative cathode efficiency is 92.5+-6%. 3 refs.; 11 figs.

8304 (JINR-D–1-13-88-172, pp. 202-205) **Self-quenching streamer drift chambers with 2.5x1.9 m dimension.** Vyskochil, S. (Joint Inst. for Nuclear Research, Dubna (USSR)); Sidorov, V.O.; Khazins, D.M.; Borisov, G.V.; Guz, Yu.P.; Lomtadze, T.A.; Tskhadadze, Eh.G. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Original desigh of self-quenching streamer drift chamber (the signal monitoring threshold is 100muA) is described. 3:1:1 argon, methane and methylal gas mixture is used. The chamber counting rates are presented. The chamber efficiency in the 3.5-4 kV voltage range is 98%. 5 refs.; 3 figs.

8305 (JINR-D–1-13-88-172, pp. 205-207) **Drift tube system for the Sigma-M spectrometer.** Denisov, D.S. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij); Eroshin, O.V.; Medovikov, V.A.; Musienko, Yu.V. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

A system of 608 drift tubes for the Sigma-M spectrometer designed for reconstruction of charged particle tracks in experiments at the IHEP accelerator and storage complex is described. As a working gas methane is used. Study of drift tube characteristics was carried out at 40 GeV/c muon beam, the intensity being 10^3 particle/s. The system operation (about 150 days) manifested its high reliability and simplisity of setting. 4 refs.; 4 figs.

8306 (JINR-D–1-13-88-172, pp. 208-210) **Mini-drift chamber.** Davydov, Yu.I. (Joint Inst. for Nuclear Research, Dubna (USSR)); Sergeev, S.V.; Strmen', P.; Feshchenko, A.A.; Fiyafin, V.B.; Chirikov-Zorin, I.E.; Shpalek, J. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Results of modelling and tests of a mini-drift chamber (MDC) with 1.3 mm drift gap are presented. It is shown that the square-type elementary cell geometry with equal electrode spacing is the optimum configuration of a plane MDC. Performance testing was carried out at 10 GeV/c charged particle beam.The chamber operation is efficient at loadings about $4x10^7$ particle/cm^{2}xs. Dependence of spatial resolution on the drift length is presented. 10 refs.; 6 figs.

8307 (JINR-D–1-13-88-172, pp. 211-213) **Cordinate wire detectors for the KASPIJ set-up.** Baldin, A.A. (AN SSSR, Moscow (USSR). Inst. Yadernykh Issledovanij); Gavriiov, Yu.K.; Kurepin, A.B.; Pantuev, V.S.; Razin, V.I.; Filippov, S.N. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Designs and parameters of several types of coordinate wire detectors: cassette proportional chambers, multiwire proportional chambers, drift chambers are described. All chambers are part of pion spectrometer settled-up at the JINR synchrotran proton beam. The curves of chambers efficiency depending on cathode voltage are presented. Coordinate accuracy of chambers is 200mum. 7 refs.; 3 figs.

8308 (JINR-D–1-13-88-172, pp. 214-216) **Performances of the proportional chambers with wire mesh and foil cathodes.** Viktorov, V.A. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij); Kurshetsov, V.F.; Novozhilov, Yu.B. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Desing and performances of proportional chambers with mesh and goil cathodes for the IHEP synchrotron experiments are described. The chambers outer dimensions are 1156x644 mm. The

test results showed that use of foil cathode is optimal both from the view point of simplifying the large chamber manufacturing technology and use of more stable wire of a larger diameter. Countering characteristics of the chamber, efficiency of single particle detection are presented. 2 refs.; 2 figs.; 1 tab.

8309 (JINR-D–1-13-88-172, pp. 220-222) **HV pulse power supplying as a way for improving proportional chamber performances during operating with intense particle beams.** Lavrent'ev, V.I. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij); Morozov, A.A.; Myalitsyn, V.K.; Chujko, B.V. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Studies of proportional chamber (PC) ageing during operation in high-intense charged particle beams are carried out. It is shown that to restore the PC efficiency interelectrode volume de-energizing is necessary. The gaol is achieved by a single remove of high voltage. During HV pulse power supply the range of operating voltage is increased by 250 V. This permits to increase the beam intensity up to 3.7×10^6 s^{-1}. 6 refs.; 5 figs.

8310 (JINR-D–1-13-88-172, pp. 223-225) **Primary ionization detection in gases by the electroluminescence chamber with longitudinal drift using the cluster count method.** Polyakov, V.A. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij); Rykalin, V.I. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

To obtain high efficiency of cluster detection the electroluminescence chamber with longitudinal drift is designed. The chamber working area is 30x30 mm, it consists of 5 cm long drift gap, 2.5 mm thick proportional counter and FEhU-85 photomultiplier, Ne + 2% acetone is a working gas mixture. Results of modellin characteristics of a large-volume detector consisting of 50 chambers which total length is 100 m are presented. Distributions of the number of pion and electron clusters at 5 GeV/c pulse and results of modelling separation coefficient in the 1-30 GeV energy range are presented. Results of measuring the chamber detection efficiency change with time at 5 and 10 GeV/c pulse at the Serpukhov accelerator are given. 11 refs.; 5 figs.

8311 (JINR-D–1-13-88-172, pp. 226-230) **Possibilities of the electroluminescence signal detection in wire chambers with the help of plastic wavelength shifters.** Volkov, A.D. (Joint Inst. for Nuclear Research, Dubna (USSR)); Zalikhanov, B.Zh.; Komissarov, E.V.; Serdyuk, V.Z.; Sidorkin, V.V.; Filimonov, I.S. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Possibility of the electroluminescence signal detection in a drift chamber with time expansion of ionization clusters is studied. The chamber was blown-through by 85% Ar + 15% CH_4 mixture and at 1550 V grid-anode voltage operated in proportional regime. Time structure of cluster signal, dependence of mean cluster number and mean interval between them on the drift field are presented. It is shown that specific operation of the drift chamber with time expansion permits to improve considerable spatial resolution of two tracks. 16 refs.; 4 figs.

8312 (JINR-D–1-13-88-172, pp. 231-233) **Wire photodetectors operating in high-current operation.** Buzulutskov, A.F. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij); Vasil'chenko, V.G.; Turchanovich, L.K. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Results of studying wire photodetectors being in high-current operation (self-quenching regime or its combination with the Geiger one) are presented. Some working gas mixtures: CH_4 + tretylamine (TEA), Ne + TEA, (CH_4 + TEA) + 7% H_2 werw studied. The most acceptable is CH_4 +TEA mixture. Photon coordinates are determined transverse to anode wire by photoelectron drift time, along the wire using the charge separation method. Spatial resolution for a design with a single anode wire were measured and constituted 1.9 and 4.5 mm respectively. 5 refs.; 4 figs.

8313 (JINR-D–1-13-88-172, pp. 234-236) **Gas-discharge particle detection with ball-shape anodes.** Travkin, V.I. (Joint Inst. for Nuclear Research, Dubna (USSR)); Khazins, D.M. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

A 15x15 cm gas-discharge chamber with ball-shape anodes is studied. The chamber consists of two plane cathodes with 11 mm spacing. In the chamber median plane 2 mm steel ball-shape anodes are mounted with 15 mm spacing. The chamber counting responses are presented. The chamber is characterized by high efficiency of charged particle detection that is 98% and has a wide range of operating voltages $\sim$ 1 kV. Use of ball-shape anodes permits to design a detector with a spherical configuration or to meet the requiment of two-coordinate detection of multiparticle events. 8 refs.; 4 figs.

8314 (JINR-D–1-13-88-172, pp. 240-242) **Study on the charged-particle spark resistive counter.** Kotel'nikov, S.K. (AN SSSR, Moscow (USSR). Fizicheskij Inst.); Kotenko, L.P. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

A design of 0.5 m^2 and more charged-particle plane spark resistive counter with 90% detection efficiency, with electrodes of simple (window) glas and 50% air + 50% propane gas filling is suggested. The counter counting response is presented. The counter time resolution is 10 ns. The counter design may be a basis for modules used lap over large areas necessary for detection of rare events, for neutrino detection in particular. 2 refs.; 3 figs.

8315 (JINR-D–1-13-88-172, pp. 253-261) **L3 uranium hadron calorimeters with wire chambers.** Kamyshkov, Yu.A. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). Inst. Teoreticheskoj i Ehksperimental'noj Fiziki). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

A design of hadron calorimeter with wire chambers for the L3 detector at LEP storage rings in CERN is described. Calorimeter cylinsrical part consists of 9 rings each containing 16 modules. Inside a module 60 proportional chambers are placed between 58 uranium plates. One module weighs 2 T. The test results of a calorimeter with 80% Ar + 20% CO_2 working mixture are presented. 3 refs.; 8 figs.

8316 (JINR-D–1-13-88-172, pp. 262-266) **SND spherical neutral particle detector for the VEPP-2M storage ring.** Aul'chenko, V.M. (AN SSSR, Novosibirsk (USSR). Inst. Yadernoj Fiziki); Aksenov, V.A.; Anashkin, V.V. and others. Joint Inst. for

Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Spherical neutral particle detector (SPD) for the VEhPP-2M storage ring experiments is constructed. SND basic body contains a three-layer spherical calorimeter with NaI (Tl) crystals, the total weight being 3.5 t. A system of drift chambers for charged particle track detection is placed in the detector central part. At present more than half of counters for the fiest two layers are fabricated. The light-collection coefficient is about 0.15. SND energy resolution estimated by the Monte Carlo method for more than 100 MeV photons is $\leq$ 10% (FWHM). 4 refs.; 5 figs.

8317 (JINR-D–1-13-88-172, pp. 267-269) **Spatial and energy resolution of the GEPARD-2000 electromagnetic spectrometer.** Pishchal'nikov, Yu.M. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij); Razuvaev, E.A. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

The GEPARD-2000 electromagnetic sectrometer is desinged and fabricated in IHEP in frames of the program of construction of the labelled neutrino complex. The detector consists of 2000 modules. Each module is 75x75 mm, its thickness is 20 rad. length by beam. The module consists of 40 scintillation and 40 lead plates (5 mm and 3 mm thick respectively). Using a thin plastic light guide covered by spectrum-shifting fiber light from each module is collected to FEhU 84-3. The GEPARD-2000 detector is characterized by high radiation resistance. Results of measuring energy resolution of the spectrometer mockup depending on the shower axis coordinate and accuracy of this coordinate determination and depending on the time coordinte value of electron incoming the detector are presented. 6 refs.; 3 figs.

8318 (JINR-D–1-13-88-172, pp. 270-272) **Performance of the electromagnetic calorimeter module with light collection on the base of spectrum-shifting fiber.** Akimenko, S.A. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij); Belousov, V.I.; Blik, A.M. and others. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

In hadron and photon hodoscopic mesh-type calorimeters consisting of netal-scintillator sandwich-modules the light is collected with the help of light guides being wavelength ahifters (WLS). Performances of calorimeter module with light collection on the base of WLS fiber spirals each responsible for up to 10 scintillation plates are studied. The calorimeter module element is of 38x38x120 mm amd contains nine 3 mm thick lead plates and nine 8 mm thick scintillation plates. Dependences of energy resolution and mean signal amplitude on coordinate of positron ectry point are presented. The mean photoelectron number from one scintillation plate when muon passes it is 1.6. Energy resolution for 5 GeV positrons is 17% (FWHM). 12 refs.; 3 figs.

8319 (JINR-D–1-13-88-172, pp. 273-275) **Application of wide-gap drift chambers for electromagnetic shower and particle detection.** Budagov, Yu.A. (Joint Inst. for Nuclear Research, Dubna (USSR)); Glagolev, V.V.; Kladiva, Eh.; Omel'yanenko, A.A.; Semenov, A.A.; Sitar, B.; Shpalek, J.; Artykov, A.M. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Wide-gap drift chambers (WDC) are used to improve spatial resolution of the Cherenkov shower hodoscopic detector used in the GIPERON spectrometer at the IHEP accelerator. Using WDC the lateral charge distribution of 13 GeV electromagnetic shower is measured. Dependence of spatial resolution of the WDC shower detector is presented. The data processing was carried out using the methods of centre of gravity, maximum and weighted maximum of electromagnetic shower charge distribution. 7 refs.; 5 figs.; 1 tab.

8320 (JINR-D–1-13-88-172, pp. 276-285) **Low temperature calorimeters as particle detectors.** Giuliani (Milan Univ. (Italy). Ist. di Fisica). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

For weakly interacting particle detection the low-temperature calorimeter: two types of superconducting detectors and bolometers are designed. The first type of the superconducting detectors contains superconducting junctions, the second one - spherical granules. Bolometer consists of three main structures: an energy absorber, a temperature sensor and an electro-thermal readout system. Bolometer operation principle and test results are described. A resolution of 36 keV for alpha particles at the temperature of 1.2 K is obtained. 38 refs.; 4 figs.

8321 (JINR-D–1-13-88-172, pp. 387-390) **Position sensitive gas discharge detector with filmless optical data readout for nn-bar oscillation search experiment at the INR AS USSR meson factory.** Gladyshev, V.A. (AN SSSR, Moscow (USSR). Inst. Yadernykh Issledovanij); Goncharenko, O.N.; Zil'berg, V.V.; Monich, E.A.; Musienko, Yu.V.; Proskuryakov, A.L.; Filippova, T.P. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

A position-sensitive gas-discharge multilayer cylindrical detector with optical data readout for neutron-antineutron oscillation search experiments at the INR AS USSR mesn factory is considered. The detector consits of 7 sections each 7 long, with the inner diameter of 2 m and the outer diameter of 3.5 m. Gas-discharge gaps are spacings between steel coaxial tubes where anode wires are tensioned. Data readout from optical fiber matrices will be carried out using teleinput system based on charge coupled matrix device with fast optical key on he base of electron-optical converter. 11 refs.; 2 figs.

8322 (JINR-D–1-13-88-172, pp. 319-325) **Transition radiation detector of electrons in experiments for asymmetry measurements in β-decay of polarized Σ^- hyperons.** Andreev, V.A. (AN SSSR, Leningrad (USSR). Inst. Yadernoj Fiziki); Vorob'ev, A.A.; Gavrilov, G.E. and others. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

A wide-aperture 12-module transition radiation detector for detection of electrons in β-decay of polarized Σ^-hyperons is designed and constructed. Each module contains a radiator of 220 polypropylene film layres and a multiwire proportional chamber. The detector was studied at a hyperon beam. Criteria for electron and π-meson identification were both ionization cluster total number and the number of operated chambers. 7 refs.; 4 figs.

8323 (JINR-D–1-13-88-172, pp. 326-331) **Application of the transition radiation detectors in UNK experiments.** Avundzhyan, A.T. (Erevanskij Fizicheskij Inst., Erevan (USSR)); Antonyan, K.G.; Kankanyan, S.A.; Oganesyan, A.G. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.*

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Requirements to the transition radiation detectors (TRD) for charged particle identification in accelerator and storage facility are given. Variaty of TRD is consodered. Results of optimization of two- and four-modular TRD containing 100 cm long module and xenon drift chamber are presentes. At present 7-m long 8-module TRD for muon energy measurement in the 0.5-5 TeV range is developed. 7 refs.; 3 figs.

8324 (JINR-D–1-13-88-172, pp. 332-343) **Silicon semiconductor coordinate detectors.** Leiste, R. (Akademie der Wissenschaften der DDR, Berlin-Zeuthen (German Democratic Republic). Inst. fuer Hochenergiephysik). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Principle of operation of silicon semiconductor coordinate detector for detection of charged particles is described. Technology of the detector fabrication is presented. The detector readout system is described. The principle of operation of charge-coupled devices is given. A silicon drift chamber with microstrip silicon detectors is proposed. 1 refs.; 14 figs.

8325 (JINR-D–1-13-88-172, pp. 344-353) **Silicon drift chambers.** Hall, G. (Imperial Coll. of Science and Technology, London (UK). Blackett Lab.). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Present status of design and fabrication of silicon drift detectors is shown. Principle of operation of this detector is described, limits to performance are presented. 11 refs.; 7 figs.

8326 (JINR-D–1-13-88-172, pp. 354-361) **FWCHA and FWCHB and its electronics in the DELPHI-detector.** Pernicka, M. (Oesterreichisches Forschungszentrum Seibersdorf G.m.b.H. (Austria). Inst. fuer Physik). Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Readout system for the DELPHI-detector is described. Electrical circuits of some devices are presented. All system modules are designed in the FASTBUS standard. 7 refs.; 15 figs.

8327 (JINR-D–1-13-88-172, pp. 362-370) **Readout electronics for different application requirements of microstrip position sensitive detectors.** Speziali, V. (Pavia Univ. (Italy)); Manfredi, P.F.; Marioli, D. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Design criteria of readout electronics for microstrip vertex detectors are considered. The basic features of these systems are presented. Such readout systems in experiments at large hadron colliders may find a satisfactory solution. 12 refs.; 3 figs.

8328 (JINR-D–1-13-88-172, pp. 371-373) **New detector electronics for experiments at colliders.** Aul'chenko, V.M. (AN SSSR, Novosibirsk (USSR). Inst. Yadernoj Fiziki); Baru, S.E.; Savinov, G.A. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Electronics for the KEDR, KMD-2 and CHD detectors aimed for experiments at colliders is designed and being manufactured and adjusted. A simple and convenient rack with fast line for the primary and secondary trigger communication is developed. Parallel processing andretrieval of information in all units is supposed. The data input velocity is $5x10^5$ words/s. 2 refs.; 2 figs.

8329 (JINR-D–1-13-88-172, pp. 374-376) **Organization of on-line operation of detecting system in the FASTBUS standard.** Parfenov, A.N. (Joint Inst. for Nuclear Research, Dubna (USSR)); Smirnov, V.A. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Organization of the FASTBUS recording electronics operation with CAMAC trunk is described. For communication of two trunks a CAMAC module is developed. Two 24-bit registers one for input and the other for output data form the module basis. The module block diagram is presented. 3 refs.; 2 figs.

8330 (JINR-D–1-13-88-172, pp. 377-381) **Development of FASTBUS modules for analog data detection from multichannel position sensitive detectors.** Vejs, M. (Joint Inst. for Nuclear Research, Dubna (USSR)); Korolev, V.S.; Parfenov, A.N.; Pilyar, A.V.; Khmelevski, E. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Development of equipmqnt for analog data detection in the FASTBUS standard has begun in JINR. For amplitude measurements of quick-changing processes analog-to-digital converters are developed. Modules are made on the basis of the parallel type ATsP 1107PV3 microcircuit with maximum conversion frequency being 100 MHz. A 16-channel time expander in the CAMAC standard and a 16-channel time interval meter in the FASTBUS atsndard are developed. Flowsheets of these sytems are presented. 9 refs.; 4 figs.

8331 (JINR-D–1-13-88-172, pp. 382-384) **Charge-sensitive amplifier. Some generalizations.** Krasnokutskij, R.N. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij); Fedyakin, N.N.; Shuvalov, R.S. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

To develop charge-sensitive amplifiers (CSA) for high-energy physics experiments in IHEP the formulas for their calculation are presented. Current and voltage transffer characteristics and CSA noise spectral densities are given. 5 refs.; 2 figs.

8332 (JINR-D–1-13-88-172, pp. 385-386) **Gated integrator.** Krasnokutskij, R.N. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij); Kurchaninov, L.L.; Tikhonov, V.V.; Fedyakin, N.N.; Shuvalov, R.S. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Analysis of noise characteristics of gated integrator is presented. Integrator equivalent circuit is given. The gated integrator permits to obtain less value of equivalent-noise current as compared with the peak detector. 7 refs.; 3 figs.

8333 (JINR-D–1-13-88-172, pp. 391-394) **Method of particle fast selection according momentum.** Kryshkin, V.I. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij); Ronzhin, A.I.

Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Analog method of particle selection according to momentum is suggested. The method lies in the following: a target is set up at the magnet entry. Emitted secondary particles are deflected by a magnetic field. The detectors in which particle trajectory coordinates are measued accoeding to the drift time are placed behind the magnet. Coincidence circuit resolution time defines the range of selected angles (momenta) and respective time coincidence of detector signals permits to select particles with the given mean momentum value. Measurement results in the IHEP synchrotron 70 GeV/c proton beam are presented. Spatial resolution for the first and second hodoscopic FEhU constituted 6+-0.3 and 8.3+-0.3 respectively. 3 refs.; 3 figs.

8334 (JINR-D–1-13-88-172, pp. 395-397) **Hodoscopes on the base of hodoscopic photomultipliers and scintillation fibers.** Alimova, T.V. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij); Vasil'chenko, V.G.; Gorin, A.M.; Zajchenko, A.A.; Prototopopov, Yu.M.; Rakhmatov, V.E.; Rykalin, V.I. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Performances of scintillation hodoscopes on the gase of one-dimensional position-sensitive hodoscopic photomultipliers are studie. Problems of spectral-shift fiber use in scintillation detectors is considered. Designs of scintillation cassette, scintillation counter and bulk scintillation detector are described. Prospects of using p-terphenyl, ppO, NaI, CsI, ZnS crystal scintillators as a scintillation medium are shown. 4 refs.; 3 figs.

8335 (JINR-D–1-13-88-172, pp. 398-400) **Controlled particle detection in nuclear emulsions.** Gushchin, E.M. (Moskovskij Inzhenerno-Fizicheskij Inst., Moscow (USSR)); Lebedev, A.N.; Somov, S.V.; Tipografshchik, G.I. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

For designing controlled emulsion charged particle detector studied on controlling the sensitivity os nuclear silver bromide emulsions in bipoar pulsed electric field (BPEF) are presented. Decisive factors permitting to control nuclear emulsion sensitivity are first os all decrease of AgBr concentration (up to 065 by weight) from localization of electron avalanche within the boundaries of activated microcrystals only and secondary use of special form of BPEF consisting of two pulses with different polarity. 5 refs.; 2 figs.

8336 (JINR-D–1-13-88-172, pp. 309-312) **Cherenkov ring spectrometer of the NEPTUN experiment.** Vasil'ev, A.N. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Serpukhov (USSR). Inst. Fiziki Vysokikh Ehnergij); Grachev, O.A.; Derevshchikov, A.A.; Kryshkin, V.I.; Ronzhin, A.I.; Rykalin, V.V.; Solov'yanov, V.L.; Khachaturov, B.A. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Test results of the Cherenkov ring spectrometer prototype for the NEPTUN experimental program are presented. The spectrometer consists of FEhU-85 and FEhU-68 matrices. Nitrogen is used as a gas radiator. The spectrometer is designed for identification of π^- and K-mesons up to 100 GeV/c. 3 figs.; 2 tabs.

8337 (JINR-D–1-13-88-172, pp. 313-315) **Development of the aerogel Cherenkov counters based on photo-recievers operating in magnetic fields.** Aksenov, V.A. (AN SSSR, Novosibirsk (USSR). Inst. Yadernoj Fiziki); Beschastnov, P.M.; Vorob'ev, A.I.; Onuchin, A.P.; Tikhonov, Yu.A.; Shamov, A.G.; Shusharo, A.I.; Kuznetsov, V.L. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

For Y-meson study at the VEhPP-4M the KEDR detector with the aerogel Cherenkov counters used for particle identification is developed. The aerogel thickness is 10 cm, its area in a counter is 20x20 cm. Each counter is tracked by two photo-recievers operating in strong magnetic fields. The detector contains 180 Cherenkov counters. Photo-recievers consist of a planar electorn-optical converter and a vacuum phototriode. 4 refs.; 1 fig.; 1 tab.

8338 (JINR-D–1-13-88-172, pp. 316-318) **Scintillation and Cherenkov detector for neutron detection in the energy range of 50-300 MeV.** Gavrilov, V.B. (Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). Inst. Teoreticheskoj i Ehksperimental'noj Fiziki); Grishchuk, Yu.G.; Degtyarenko, P.V.; Efremenko, Yu.V. Joint Inst. for Nuclear Research, Dubna (USSR). 1988. (In Russian). (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). In *International symposium on position detectors in high energy physics. Proceedings.* Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

For separation of neutron and gamma photon detection signals a detector consisting of alternating scintillator and Cherenkov radiator layers is developed. Test results of the detector with the working area of 7 NE 102A type scintillator plates and 7 Cherenkov radiator plates (polymethylmetacrylate) are presented. The plates are 200x150x15 mm. The FEhU-63 photomultipliers are used. Exrosure was carried out in the 3 GeV/c π-meson beam. The target material is carbon. At the neutron detection threshold of 40 MeV, more than 95% of gamma photons are identified. 2 refs.; 4 figs.

8339 (LA-UR–89-2970) **Status of the expansion of the CYGNUS array at Los Alamos.** Berley, D. (Maryland Univ., College Park, MD (USA)); Chang, C.Y.; Dingus, B.L.; Goodman, J.A.; Haines, T.J.; Stark, M.; Burman, R.L.; Cady, D.R.; Hoffman, C.M.; Lloyd-Evans, J.; Nagle, D.E.; Potter, M.E.; Sandberg, V.D.; Wilkinson, C.A.; Alexandreas, D.E.Los Alamos National Lab., NM (USA). [1989]. 5p. Sponsored by U.S. DOE Energy Research. DOE Contract W-7405-ENG-36. (CONF-900122–2: 21. international cosmic ray conference, Adalaide (Australia), 6-19 Jan 1990). Order Number DE89016781. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

The CYGNUS air shower array, located in Los Alamos, New Mexico, has been operating since April, 1986. The expansion of the array from 108 to 200 counters is described along with the increase in muon detection area. The new array, to be fully operational by the end of 1989, will have three times the sensitivity to UHE sources. 5 refs., 2 figs.

8340 (ORNL–6593) **The development, characterization, and performance evaluation of a new combination type personnel neutron dosimeter.** Liu, J.C. (Oak Ridge National Lab., TN (USA)); Sims, C.S.; Poston, J.W. Oak Ridge National Lab., TN (USA). Oct 1989. 200p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004408. Available from NTIS, PC A10/MF A01 - OSTI; GPO Dep.

A new combination type personnel neutron dosimeter has been designed and developed at the Oak Ridge National Laboratory (ORNL). The combination personnel neutron dosimeter (CPND) consists of a Harshaw albedo neutron thermoluminescent dosimeter (two pairs of TLD-600/TLD- 700) and two bubble detectors (one BD-100R and one BDS-1500 from Bubble Technology Industries, Canada). The CPND was developed with the aim of having crude neutron spectrometric capability, universal applicability, better angular response, and an improved lower limit of detection (LLD). The

CPND has been well characterized in the following areas: reusability, linearity, lower limit of detection (LLD), detection capability in mixed neutron-gamma fields, angular dependence, and neutron energy dependence. the characterization was accomplished with irradiations using a ^{238}Pu-Be source, a ^{252}Cf(D_2O) source, a ^{252}Cf source, a ^{252}Cf(PE) source, monoenergetic neutrons from accelerator and reactor filtered beams, ^{137}Cs, and X-rays. Optimum signal readout procedures, signal processing techniques, routine operational usage, and neutron dose equivalent evaluation algorithms for the CPND were developed with the goals of having the best precision and accuracy as well as being convenient to use. 97 refs., 43 figs., 22 tabs.

8341 (RAL–89-060) **Development studies for the OPAL end cap electromagnetic calorimeter using vacuum photo triode instrumented leadglass.** Jeffreys, P.W. (Rutherford Appleton Lab., Chilton (UK)); Arnison, G.T.J.; Akrawy, M.;. Rutherford Appleton Lab., Chilton (UK). Jul 1989. 55p. Order Number DE90612635. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

A description is given of the OPAL end cap electromagnetic calorimeters which consist of leadglass instrumented with vacuum photo triodes. Test results are presented showing linearity, energy and position resolution measured in an electron beam whilst the calorimeter is subject to magnetic fields up to 1.0T. The response to hadrons is also discussed. Finally, radiation damage and recovery of the leadglass is reported. (author).

8342 (RAL–89-063) **A modular amplifier system for the readout of silicon strip detectors.** Thomas, S.L. (Rutherford Appleton Lab., Chilton (UK)); Davinson, T.; Shotter, A.C.;. Rutherford Appleton Lab., Chilton (UK). Jul 1989. 20p. Order Number DE90612646. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

A modular system of 250 pre-amplifiers and shaping amplifiers is being built to read out an array of silicon strip detectors. The detectors form a telescope which is used to study the break up reactions of heavy ions in vacuum. A charge sensitive pre-amplifier connected to each strip amplifies the signal before it is passed to the second stage of amplification and shaping. The final signal is converted to digital form before processing by a computer, where information on particle identity, scattering direction and energy is extracted. The pre-amplifiers have been designed as thick-film hybrids which plug into a mother-board from which twisted-pair cables carry the signals to the shaping amplifiers out-side the chamber. The shaping amplifiers are surface-mounted boards, plugged into a Eurocard to which the cables are attached. The amplifiers feature three stages of shaping and a gain which can be adjusted by changing resistor packages on the Eurocard. The linearity of the amplifiers is better than 0.1% for outputs up to 10V, with a peaking time of 1 musecond. The output noise is below 1.0mV rms at maximum gain, equivalent to 500 electrons rms in the detector. (author).

8343 (RAL–89-075) **A comparison of Kodak DEF Industrex CX and Industrex AX films at soft x-ray wavelengths.** Ridgeley, A.; Foster, N.L.;. Rutherford Appleton Lab., Chilton (UK). Jul 1989. 7p. Order Number DE90612647. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS.

Kodak direct exposure film (DEF), and the Kodak Industrex films CX and AX have been compared, using a DC X-ray source to generate 1.5 keV soft X-rays. Characteristic curves are presented for the three films, also detective quantum efficiencies as a function of incident X-ray flux. The effect of developer temperature on the characteristic curve has also been investigated. (author).

8344 (SLAC–354) **SLD physics studies: Proceedings of the SLD physics week.** Stanford Linear Accelerator Center, Menlo Park, CA (USA). Oct 1989. 680p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00515. (CONF-8907149–: SLD physics studies: SLD physics week, Kirkwood, CA (USA), 31 Jul - 4 aug 1989). Order Number DE90004368. Available from NTIS, PC A99/MF A01; OSTI; INIS; GPO Dep.

This report contains papers on the following topics relating to SLD physics: electroweak parameter and QCD tests; heavy quark spectroscopy; $B\bar{B}$ mixing and CP violations; search for supersymmetry; search for technicolor; and search for new quarks, leptons and Z's.

8345 (UCRL–101246) **8 keV x-ray zone plates.** Bionta, R.M.; Ables, E.; Clamp, O.; Edwards, O.D.; Gabriele, P.C.; Makowiecki, D.; Ott, L.L.; Skulina, K.M.; Thomas, N. Lawrence Livermore National Lab., CA (USA). 5 Jun 1989. 8p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. (CONF-890836–21: 33. SPIE annual international technical symposium on optical and optoelectronic applied science and engineering, San Diego, CA (USA), 6-11 Aug 1989). Order Number DE90003837. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Sputtered-sliced transmissive x-ray zone plates consisting of concentric rings of Al and Cu have been fabricated and tested using the 8.04 keV k-α line from Cu. Due to the need for high aspect ratios for this 1.54 Å radiation, magnetron sputtering onto a rotating opaque central wire was chosen as the fabrication method. Both the fabrication technology and initial results are presented. 11 refs., 4 figs.

8346 **Rutherford backscattering and Auger spectroscopy of mercuric iodide detectors.** Felter, T.E. (Sandia National Labs., Livermore, CA (USA)); Stulen, R.H.; Schnepple, W.F.; Ortale, C.; Van den Berg, L. *Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors, and Associated Equipment (Netherlands)*, 283(2): 195-198 (1 Nov 1989). DOE Contract AC04-76DP00789.

Palladium contacts on mercuric iodide have been studied using Rutherford backscattering spectroscopy and Auger electron spectroscopy. Results on actual detector contacts show some intermixing of both mercury and iodine with the palladium. To investigate the role of processing variables as a possible cause of this effect we have fabricated model contacts at low temperatures ($T \simeq 100$ K) and analyzed in situ. The results demonstrated that significant interdiffusion occurs at temperatures as low as 225 K. We conclude that excessive heating during contact deposition could prove to be detrimental to device performance and that the use of cooled substrates during processing should be explored. (orig.).

8347 **Pinhole plate diagnostic for neutral particle beam accelerator.** Barthell, B.L. (Los Alamos National Lab., NM (USA)); Archuleta, T.A. *Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors, and Associated Equipment (Netherlands)*, 282(1): 169-171 (1 Oct 1989). (CONF-8809159–: 14. world conference of the International Nuclear Target Development Society (INTDS): heavy-ion targets and related phenomena, Darmstadt (Germany, F.R.), 5-9 Sep 1988).

An unusual method of forming a foil with highly accurate hole placements and overlayed stripper/neutralizer foil allows accurate beam divergence and density diagnostics when used in conjunction with a downstream fluorescent screen and high resolution photography. (orig.).

8348 **Measurements of heat capacities, temperatures, and absorptivities of single particles in an electrodynamic balance.** Monazam, E.R. (U.S. Department of Energy, Morgantown Energy Technology Center, P. O. Box 880, Morgantown, West Virginia 26507-0880 (US)); Maloney, D.J.; Lawson, L.O. *Review of Scientific Instruments (USA)*, 60(11): 3460-3465 (Nov 1989).

A rapid measurement technique to determine heat capacities, temperatures, and absorptivities of single submillimeter size (50–200 μm diam) particles in an electrodynamic balance (EDB) is described. Accurate estimates of heat capacities and absorptivities are made for single carbon particles at temperatures ranging from 800 to 1200 K with measurement times of less than 0.5 s. Measurements are made by isolating and holding charged particles at the null position in an EDB. Particles are heated using the output from a well-characterized CO_2 laser which is modulated to provide heating pulses of 3-ms duration at a repetition rate of 100 Hz. The resulting periodic temperature oscillations are monitored continuously using a single wavelength high-speed optical pyrometer. Heat capacities and absorptivities are determined based on comparisons of the recorded heating and cooling profiles with theoretical predictions obtained from numerical solution of the Fourier equation. Experimentally determined heat capacities for carbon spheres are in excellent agreement ($\pm$10%) in terms of their absolute value and temperature dependence when compared with published heat capacity correlations for chars and graphite. Absorptivity estimates are also in excellent agreement with published values for carbons.

4402 Radiation Effects on Instrument Components, Instruments, or Electronic Systems

Refer also to citation(s) 8203

8349 (SAND–89-2277C) **Overview on radiation effects in electronics.** Dawes, W.R. Jr. (Sandia National Labs., Albuquerque, NM (USA)). Sandia National Labs., Albuquerque, NM (USA). [1989]. 7p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-900109–6: 7. symposium on space nuclear power systems, Albuquerque, NM (USA), 7-11 Jan 1990). Order Number DE90000841. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The radiation spectrum constituents of interest to microelectronics are prompt gamma or x-ray, total dose, neutrons (or protons), and cosmic radiation. Each of these constituents has a unique effect upon microelectronic components and requires unique techniques to improve the microelectronic radiation tolerance to such an exposure. This paper reviews the radiation effects associated with the natural space and nuclear reactor radiation environment, that is to say, total dose, neutrons, and cosmic rays. 2 refs., 6 figs.

8350 **Radiation effects in semiconductor laser diode arrays.** Carson, R.F. (Sandia Labs., Albuquerque, NM (USA)). pp. 262 of Optoelectronic materials, devices, packaging, and interconnects II. McWright, G.M.; Wojtunik, H.J SPIE Society of Photo-Optical Instrumentation Engineers, Bellingham, WA (1988). (CONF-8809111–: Optoelectronic materials, devices, packaging, and interconnects II, Boston, MA (USA), 6-10 Sep 1988).

The effects of radiation events are important for many present and future applications that involve optoelectronic components. Laser diodes show a strong resistance to degradation by gamma rays, prompt x-rays and (to a lesser extent), neutrons. This is due to the short carrier lifetime that is associated with stimulated emission and the high current injection conditions that are present in these devices. Radiation-resistant properties should carry over to many of the more recently developed devices such as multi-stripe array and broad area laser diodes. There are however, additional considerations for radiation tolerance that are introduced by these devices. Arrays and other high power laser diodes have larger active region volumes than lower power single stripe devices. In addition, evanescent field coupling between stripes, the material quality available from newer MOCVD epitaxial growth techniques, and stripe definition methods amy all influence the radiation tolerance of the high power laser diode devices. This paper discusses radiation tests conducted on various GaAs-GaAlAs laser diode array and broad area devices.

8351 **Radiation-induced changes in magnetic properties of Nd-Fe-B permanent magnets.** Brown, R.D. (Los Alamos National Lab., NM (USA)); Cost, J.R. *IEEE (Institute of Electrical and Electronics Engineers) Transactions on Magnetics (USA),* 25(4): 3117-3120 (Jul 1989).

The high remanence and intrinsic coercivity of Nd-Fe-B magnets make them desirable for use in accelerators. Use in the radiation environment of an accelerator requires that the sensitivity of these magnets to radiation be determined and the mechanisms responsible for degradation be understood. Small magnets were irradiated at the Omega West Reactor in a fast neutron flux of 4×10^{12} n/cm^2 . s at a temperature of 350 K (77^{0}C). At various time intervals during the irradiation, samples were removed from the reactor and the open-circuit remanence measured. The authors show that the rate of remanence decay decreases monotonically with increasing length-to-diameter (L/D) ratio for samples of the same material. Thus when comparing different materials, it is important that the samples have a fixed L/D ratio. Samples of different materials having an L/D ratio of 4.4 were neutronirradiated to study the decay of the remanence. Their results show that the sensitivity to radiation varies widely amount magnets from different vendors. Possible reasons for this variation are investigated and discussed.

4405 Thermal Instrumentation

8352 (WSRC-RP–89-1170) **Survey of thermal imaging technology and applications at the Savannah River Site.** Westinghouse Savannah River Co., Aiken, SC (USA). 9 Oct 1989. 12p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. Order Number DE90003926. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This memorandum is an introduction to thermal imaging systems and their use. Emission of infrared radiation from ideal and real materials is described, as are methods of detection in modern thermal imaging systems. Typical specifications and features of commercially available thermal imaging systems are described, and uses of thermal imaging are discussed. At the Savannah River Site (SRS), thermal imaging has been used extensively to measure the temperature of surface water that carries heat from the reactors to the Savannah River. Other uses at SRS have been surveying roof insulation and moisture, evaluating insulation of prototype glass melters at the TNX facility, and locating leaks in the Concentrate Transfer System. Future recommended programs include evaluating thermal imaging for general monitoring of plant facilities, especially electrical conduits, processes occurring at elevated temperature, and radioactive storage areas that generate significant amounts of waste heat. Research on the resistance weld techniques used in tritium reservoir handling (pinch welding and reclamation welding) may profit from high speed thermal image monitoring of heat generated during welding, and other Process Development activities may also benefit from high-speed thermal image monitoring. 12 refs., 1 fig.

4406 Optical Instrumentation

Refer also to citation(s) 8074

8353 (BNL–42519) **Surface topography measurements over the 1 meter to 10 micrometer spatial period bandwidth.** Takacs, P.Z. (Brookhaven National Lab., Upton, NY (USA)); Furenlid, K.; DeBiasse, R.A.; Church, E.L. Brookhaven National Lab., Upton, NY (USA). Sep 1989. 9p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-890836–20: 33. SPIE annual international technical symposium on optical and optoelectronic applied science and engineering, San Diego, CA (USA), 6-11 Aug 1989). Order Number DE90003642. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A recently-developed long-trace surface profiling instrument (LTP) is now in operation in our laboratory measuring surface profiles on grazing incidence aspheres and also conventional optical surface. The LTP characterizes surface height profiles in a non-contact manner over spatial periods ranging from 1 meter (the maximum scan length) to 2 mm (the Nyquist period for 1 mm sampling period) and complements the range of our WYKO NCP-1000 2.5X surface roughness profiler (5 mm to 9.8 μm). Using these two instruments, we can fully characterize both figure and finish of an optical surface in the same way that we normally characterize surface finish, e.g., by means of the power spectral density function in the spatial frequency domain. A great deal of information about the distribution of figure errors over various spatial frequency ranges is available from this data, which is useful for process control and predicting performance at the desired wavelength and incidence angle. In addition, the LTP is able to measure the absolute radius of curvature on long-radius optics with high precision and accuracy. Angular errors in the optical head are measured in real time by an electronic autocollimator as the head traverses the linear air bearing slide. Measurements of kilometer radius optics can be made very quickly and the data analyzed in a format that is very easy to understand. 17 refs., 10 figs.

8354 (WSRC-RP–89-1171) **Survey of digital imaging technology and applications at the Savannah River Site.** Westinghouse Savannah River Co., Aiken, SC (USA). 9 Oct 1989. 11p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. Order Number DE90003927. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

An introduction to methods of digital image analysis is presented. Modern commercially available digital image analysis systems are described, along with applications that may be useful to programs at the Savannah River Site (SRS). Systems to aid inspection of tritium reservoir fill stems and a system to enhance inspection of radiographs of pinch weld closures of tritium reservoirs have already been developed at SRS. Modern digital analysis systems based on personal computers have been and are being procured for use in

Savannah River Laboratory (SRL) programs, and are finding immediate application in several programs requiring quantitative metallography. It is argued that x-ray computed tomographic imaging, digitally-enhanced ultrasonic testing and acoustic microscopy are three techniques that would enhance not only the research and development efforts at SRL, but also may be applicable in production (for example, in pinch and reclamation welding of tritium reservoirs, and in reactor component inspection) as quality assurance and documentation tools. 21 refs.

4408 Miscellaneous Instrumentation

Refer also to citation(s) 6774, 6971, 7508, 7731, 8018, 8072, 8159, 8174, 8196, 8251, 8267

8355 (Juel-Spez–451) **Design and construction of a thyratron trigger circuit for a high-voltage pulse receiver.** Bongers, N. Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Inst. fuer Schicht- und Ionentechnik; Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Projektleitung COSY. Jun 1988. 58p. (In German). Order Number DE90732320. Available from NTIS (US Sales Only), PC A04/MF A01.

The demand to run the rapid soft radiation in COSY with a hydrogen thyratron has led to the question of an appropriate control method for this thyratron. A new method of igniting the thyratron is being applied in view of new semiconductor units, the rapid power MOS-FETs. (orig./HP).

8356 (MSHA/IR–1163) **Evaluation of four fast-response flow measurement devices.** Gero, A.J.; Suppers, K.L.; Tomb, T.F. Mine Safety and Health Administration, Denver, CO (USA). 1988. 9p. Sponsored by U.S. Department of Labor. Order Number DE90003743. Available from NTIS, PC A02/MF A01 - OSTI.

The Federal Mine Safety and Health Act of 1977 requires that sampling of dust in coal mine environments be conducted with an approved sampler operating at a flow rate of 2.0 liters of air per minute or at such other flow rate as prescribed by the Secretaries of Labor and of Health and Human Services. Standard procedures for calibration of these samplers within the Mine Safety and Health Administration utilize either a 3.0 liter capacity wet test meter or a 1.0 liter soap film calibrator. Several new flow calibrating devices have become commercially available. This paper describes an evaluation conducted on four such devices: the Mast Model 823-2 bubble flowmeter, the Buck Calibrator, the Kurz Model 541S mass flowmeter and the Kurz Pocket Calibrator. The precision of a series of measurements made with each instrument was compared to the precision of a series of measurements made with the wet test meter. The comparison showed that the variability of calibration measurements obtained with the fast response flow calibrators was between 1.5 and 4.5 times larger than that obtained with the WTM; however, with all of the calibration devices evaluated, three repetitive measurements were sufficient to obtain a precision of ± 0.1 liters per minute. 4 refs., 2 figs., 1 tab.

8357 **Phase-gradient algorithm as an optimal estimator of the phase derivative.** Eichel, P.H. (Sandia National Laboratories, Albuquerque, New Mexico 87185 (US)); Jakowatz, C.V.,Jr. *Optics Letters (USA),* 14(20): 1101-1103 (15 Oct 1989).

The phase-gradient algorithm represents a powerful new signal-processing technique with applications to aperture-synthesis imaging. These include, for example, synthetic-aperture-radar phase correction and stellar-image reconstruction. The algorithm combines redundant information present in the data to arrive at an estimate of the phase derivative. We show that the estimator is in fact a linear, minimum-variance estimator of the phase derivative.

8358 **Two-dimensional phase correction of synthetic-aperture-radar imagery.** Ghiglia, D.C. (Sandia National Laboratories, Albuquerque, New Mexico 87185 (US)); Mastin, G.A. *Optics Letters (USA),* 14(20): 1104-1106 (15 Oct 1989). DOE Contract AC04-76DP00789.

A two-dimensional synthetic-aperture-radar (SAR) phase-correction algorithm is described as a natural extension of a one-dimensional technique developed previously. It embodies some similarities of phase-gradient speckle imaging and incorporates improvements in phase estimation. Diffraction-limited performance has been obtained on actual SAR imagery regardless of scene content or phase-error structure. The algorithm is computationally efficient, robust, and easily implemented on a general-purpose computer or special-purpose hardware.

8359 **Direct phase estimation from phase differences using fast elliptic partial differential equation solvers.** Ghiglia, D.C. (Sandia National Laboratories, Albuquerque, New Mexico 87185 (US)); Romero, L.A. *Optics Letters (USA),* 14(20): 1107-1109 (15 Oct 1989). DOE Contract AC04-76DP00789.

Obtaining robust phase estimates from phase differences is a problem common to several areas of importance to the optics and signal-processing communities. Specific areas of application include speckle imaging and interferometry, adaptive optics, compensated imaging, and coherent imaging such as synthetic-aperture radar. We derive in a concise form the equations describing the phase-estimation problem, relate these equations to the general form of elliptic partial differential equations, and illustrate results of reconstructions on large M by N grids, using existing, published, and readily available FORTRAN subroutines.

8360 **New family of binary arrays for coded aperture imaging.** Gottesman, S.R. (Grumman Corporate Research Center, Bethpage, New York 11714 (US)); Fenimore, E.E. *Applied Optics (USA),* 28(20): 4344-4352 (15 Oct 1989).

We introduce a new family of binary arrays for use in coded aperture imaging which are predicted to have properties and sensitivity (SNR) equal to that of the uniformly redundant array (URA). The new arrays, called MURAs (modified URAs), have decoding coefficients all of which are unimodular, resulting in a reconstructed image with noise terms completely independent of image–source structure. Although the new arrays are derived from quadratic residues, they do not belong to the cyclic difference set or set of pseudonoise sequences and consequently are constructible in configurations forbidden to those designs, thus providing the user with a wider selection of aperture patterns to match his particular needs. With the addition of MURAs to the family of binary arrays, all prime numbers can now be used for making optimal coded apertures, increasing the number of available square patterns by more than a factor of 3.

8361 **Electrically induced transmissivity modulation in polymeric thin film Fabry-Perot etalons.** Eldering, C.A. (University of California, Davis, Department of Electrical Engineering & Computer Science, Organized Research Program on Polymeric Ultrathin Film Systems, Davis, California 95616 (US)); Kowel, S.T.; Knoesen, A. *Applied Optics (USA),* 28(20): 4442-4445 (15 Oct 1989).

We report the observation of electrically induced changes in transmissivity in Fabry-Perot devices consisting of spin-cast azo-dye/polymer films deposited between gold mirrors. In poled samples the observed modulation shows a linear dependence on the applied modulating voltage. The ratio of the transmissivity modulation observed using incident transverse magnetic polarization to that observed using transverse electric polarization is used to demonstrate that the electrooptic effect dominates the modulation. This is, to our knowledge, the first reported use of a polymeric thin film linear electrooptic material in a Fabry-Perot structure and demonstrates the use of etalons to enhance electrooptic effects in very thin films.

45 MILITARY TECHNOLOGY, WEAPONRY, AND NATIONAL DEFENSE

Refer also to citation(s) 6882

8362 (CONF-8906256–1) **Logistics Intra-Theater Support Tool: Combining artificial intelligence and operations research techniques.** Van Groningen, C.N.; Duffy, M.K.; Widing, M.A.; Macal, C.M. Argonne National Lab., IL (USA). [1989]. 16p. Sponsored by U.S. Department of Defense. DOE Contract W-31109-ENG-38. From 57. military operations research symposium; Fort Leavenworth, KS (USA); 6-8 Jun 1989. Order Number DE90003820. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The Logistics Intra-theater Support Tool (LIST) is a prototype system that analyzes courses of action to see if they are logistically feasible. A course of action (COA) specifies the movement of a

specified combat force, its supporting forces, and its supplies to a location by a certain time. LIST answers the following questions. Is the intra-theater infrastructure capable of meeting the COA requirements given the assigned resources? If the COA is not logistically feasible, what are the bottlenecks? How could the COA be modified to improve its feasibility? 8 refs., 10 figs.

8363 (ORNL/TM–11201) **A decision support system for the Military Airlift Command, the Airlift Deployment Analysis System.** Kraemer, R.D.; Harrison, I.G. Oak Ridge National Lab., TN (USA). Sep 1989. 38p. Sponsored by U.S. Department of Defense. DOE Contract AC05-84OR21400. Order Number DE90004354. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Oak Ridge National Laboratory (ORNL) is assisting the Military Airlift Command (MAC) with the development of the Airlift Deployment Analysis System (ADANS). ADANS will improve MAC's automated capabilities for scheduling peacetime airlift missions, deliberate planning, execution planning, and analysis of the airlift system. ADANS will consist of four subsystems: airlift planning and scheduling algorithms, database management, user interface, and communications. This paper describes MAC's current airlift planning and scheduling operations, the current automated systems used to develop airlift schedules and plans, approaches to developing ADANS, and major improvements that will result from the implementation of ADANS. This report is based on a series of in-depth interviews and working sessions that were conducted with MAC staff, a review of airlift scheduling literature, and the ongoing research effort at ORNL for the ADANS project. 9 refs., 2 figs., 2 tabs.

4501 Chemical Explosions and Explosives

Refer also to citation(s) 8118, 8121

8364 (MLM–3609) **More efficient sensitivity testing.** Neyer, B.T. EG and G Mound Applied Technologies, Miamisburg, OH (USA). 20 Oct 1989. 31p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-88DP43495. Order Number DE90002639. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A new sensitivity test which has many advantages over the previously defined tests was developed. Computer simulation demonstrated that this new test provides better estimates (less bias and smaller variance) of both the mean, μ, and the standard deviation, σ, than the other known tests. Theoretical analysis and simulation suggest that this test will generally be the most efficient sensitivity test possible. Thus, use of this test should result in savings of both time and components without loss of precision. 14 refs., 13 figs.

4502 Nuclear Explosions and Explosives

8365 (ORNL/TM–11193) **Fallout facts for nuclear-battlefield commanders.** Haaland, C.M. Oak Ridge National Lab., TN (USA). Sep 1989. 74p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC05-84OR21400. Order Number DE90004353. Available from NTIS, PC A05/MF A01 - OSTI; GPO Dep.

The basic phenomenology of radioactive fallout from nuclear detonations is described nonmathematically for military commanders who may become engaged in nuclear battle. Subjects include a description of fallout debris, the process of formation and deposition, and hazards to personnel. Comparisons are made between initial nuclear radiation and radiation from fallout. A radiation rate and exposure forecasting method is presented for situations where the source of fallout and rate of decay are unknown. Additional research is recommended for (1) development of improved methods for estimating casualties resulting from combined exposure to initial nuclear radiation and fallout radiation; and (2) improving the estimate of the K-factor (how much of the radioactive material comes to the ground as early fallout). 76 refs., 23 figs., 9 tabs.

8366 (SSS-R–82-5410) **Evolution of the post-shot cavity and tunnel system thermodynamic states.** Peterson, E.W.; Lie, K. S-Cubed, La Jolla, CA (USA). 21 Mar 1984. 108p. Sponsored by U.S. Department of Defense. DNA 001-83-C-0057. Order Number DE90003445. Available from NTIS, PC A06/MF A01 - OSTI.

A comprehensive leak model has been developed. This model determines the cavity volume and cavity gas thermodynamic state, describes leak-channel formation through the stemming column, and includes cavity and tunnel mass and energy loss mechanisms associated with heat transfer or fluid diffusion. Because of the difficulty in defining such complex phenomena, simple engineering descriptions were used as building blocks which were subsequently integrated into a comprehensive model. Predicted results were compared to the measured HUDSON MOON data. 28 refs., 35 figs., 5 tabs.

8367 (UCRL–100960) **MIGHTY OAK containment review.** Brownlee, R.R. (Los Alamos National Lab., NM (USA)); Chabai, A.J.; Higgins, G.H.; Hudson, B.C.; LaComb, J.W.; Peterson, E.W. Lawrence Livermore National Lab., CA (USA). Sep 1989. 12p. Sponsored by U.S. Department of Defense. DOE Contract W-7405-ENG-48. (CONF-8909163–11: 5. symposium on containment of underground nuclear detonations, Santa Barbara, CA (USA), 19-21 Sep 1989). Order Number DE90003619. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

MIGHTY OAK was conducted on April 10, 1986, below the surface of Rainier Mesa in the T-tunnel complex. Containment of MIGHTY OAK was satisfactory in that there was no accidental release of radioactivity to the atmosphere whatsoever. However, the tunnel grout in the near-cavity region was not sufficiently constrained. Failure of this plug led to the subsequent failure of the mechanical closure systems and to the eventual flow of cavity gas, plug material, and other debris down the line-of-sight (LOS) pipe to the experiment chamber and the tunnel complex beyond. Because of the resulting damage to equipment and facilities, a significant portion of the MIGHTY OAK containment related diagnostics data was lost. Consequently, little direct information is available concerning why the ground-motion/LOS pipe closure process failed to form an adequate plug. However, we have made an extensive review of relevant information available, including the containment system design, site geologic structure and materials property data, as-built installations, and previous experience. As a result, we have identified three design modifications that together we feel would have prevented the observed failure. These include: (1) using a mechanical LOS closure and abutment that has been strengthened to provide better confinement of the grout plug; (2) using alternating lengths of strong and weak grout to fill the LOS drift between the cavity and the MAC to avoid excessive motion (and loss) of the weak grout; and (3) using grout materials whose composition is such that that their behavior will be reliable and reproducible. Additionally, we recommend improving the capabilities of the mechanical LOS closures so they better complement the ground-motion-induced closure. Other, more general recommendations are included in the following report. 3 figs.

8368 (UCRL–101156) **Strain hardening in salt–results of the SALMON experiment.** Glenn, L.A. (Lawrence Livermore National Lab., CA (USA)). Lawrence Livermore National Lab., CA (USA). 2 Jun 1989. 17p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. (CONF-900102–1: 13. energy-sources technology conference and exhibition, New Orleans, LA (USA), 14-18 Jan 1990). Order Number DE89014041. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

SALMON was a nuclear explosion in the Tatum salt dome, near Hattiesburg, Mississippi, that took place on October 22, 1964. Computational attempts to simulate the experimental results had been largely unsuccessful. Recent calculations suggest that the reason is that the salt yield strength is extremely sensitive to strain hardening. The hardening effect had not been observed in laboratory-scale measurements, which were not made at small enough strain levels and may not have been representative of in situ pore-fluid pressure. 10 refs., 7 figs.

8369 **The effective yield of a nuclear explosion in a small cavity in geological material: Enhanced coupling revisited.** King, D.S. (Los Alamos National Laboratory, Los Alamos, New Mexico (US)); Freeman, B.E.; Eilers, D.D.; Johnson, J.D. *Journal of Geophysical Research (USA),* 94(B9): 12375-12386 (10 Sep 1989).

The hydrodynamic yield of an underground nuclear explosion in a small cavity has been recalculated using computer modeling. We have considered explosions in spherical cavities having scaled radii,

$R/W^{1/3}$, less than 3.5 m/kt$^{1/3}$ (R is the cavity radius in meters and W is the explosion energy in kilotons) in quartz (SiO_2) using an available equation of state (Ree, 1976). These calculations show, at a scaled radius of ≈1.5 m/kt$^{1/3}$, a maximum hydrodynamic yield substantially greater than that of an explosion in a tamped cavity (enhanced coupling) as measured by the shock time of arrival in the near field. These results are in qualitative agreement with those of earlier investigators who utilized the reduced displacement potential to evaluate coupling. We found, however, that the coupling coefficient (ratio of yield for cavity model to yield for tamped model) is significantly reduced when an improved quartz equation of state is employed. We also calculated enhanced coupling in two additional geologic materials, salt and tuff. All of the calculations mentioned above (including our initial ones) were simplified through the omission of significant thermal radiation contributions to energy and pressure in the cavity and the diffusion by photon transport of energy from the explosion cavity into the adjacent rock. When we take these processes into account, we find that for a cavity radius of approximately 1.5 m/kt$^{1/3}$, near the peak of enhancement for our models with no radiation, there is instead decoupling of about 15% in SiO_2, 20% in tuff, and about 15% in salt.

4503 Nuclear Explosion Detection

Refer also to citation(s) 7881

4504 Nuclear and Radiological Warfare

Refer also to citation(s) 8364

4506 Chemical and Biological

8370 (ORNL/TM–11092) **Emergency response concept plan for Pine Bluff Arsenal and vicinity.** Carnes, S.A.; Sorensen, J.H.; Rogers, G.O.; Shumpert, B.L.; Miller, R.L.; Watson, A.P.; Chester, C.V. Oak Ridge National Lab., TN (USA). Oct 1989. 80p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004360. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The continued storage and disposal of the United States' unitary chemical stockpile, including that portion stored at Pine Bluff Arsenal (PBA) near Pine Bluff, Arkansas, have the potential for accidental releases that could escape installation boundaries and pose a threat to civilian populations. The US Army, in conjunction with the Federal Emergency Management Agency and other federal agencies, is committed to implement an emergency preparedness program that will significantly reduce the probability of adverse effects from such releases. This concept plan, which is but a part of a comprehensive ongoing effort, provides a framework for initiating such a program for the PBA stockpile. This report develops information and methodologies that bear on two major decisions for such a program – determining emergency planning zones and selecting protective action strategies. These decisions are based on the hazards posed by the PBA stockpile and its disposal. These hazards, in turn, are based largely on the distribution of potential accidental releases associated with interim storage and disposal activities and associated external events (e.g., earthquakes and airplane crashes), the distribution of natural features that can affect an agent release (topological features and meteorological characteristics), and the distribution of people and resources (e.g., homes, schools, and hospitals) potentially affected by an accidental release. 23 refs., 9 figs., 12 tabs.

8371 (ORNL/TM–11093) **Emergency response concept plan for Anniston Army Depot and vicinity.** Carnes, S.A.; Sorensen, J.H.; Rogers, G.O.; Shumpert, B.L.; Miller, R.L.; Watson, A.P.; Chester, C.V. Oak Ridge National Lab., TN (USA). Oct 1989. 123p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004361. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The continued storage and disposal of the United States' unitary chemical stockpile, including that portion stored at Anniston Army Depot (ANAD) near Anniston, Alabama, have the potential for accidental releases that could escape installation boundaries and pose a threat to civilian populations. The US Army, in conjunction with the Federal Emergency Management Agency and other federal agencies, is committed to implement an emergency preparedness program that will significantly reduce the probability of adverse effects from such releases. This concept plan, which is but a part of a comprehensive ongoing effort, provides a framework for initiating such a program for the UMDA stockpile. This report develops information and methodologies that bear on two major decisions for such a program – determining emergency planning zones and selecting protective action strategies. These decisions are based on the hazards posed by the UMDA stockpile and its disposal. These hazards, in turn, are based largely on the distribution of potential accidental releases associated with interim storage and disposal activities and associated external events (e.g., earthquakes and airplane crashes), the distribution of natural features that can affect an agent release (topographical features and meteorological characteristics), and the distribution of people and resources (e.g., homes, schools, and hospitals) potentially affected by an accidental release. 25 refs., 9 figs., 13 tabs.

8372 (ORNL/TM–11094) **Emergency response concept plan for Tooele Army Depot and vicinity.** Carnes, S.A.; Sorensen, J.H.; Rogers, G.O.; Shumpert, B.L.; Miller, R.L.; Watson, A.P.; Chester, C.V. Oak Ridge National Lab., TN (USA). Oct 1989. 80p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004362. Available from NTIS, PC A07/MF A01 - OSTI; GPO Dep.

The continued storage and disposal of the United States' unitary chemical stockpile, including that portion stored at Tooele Army Depot (TEAD) near Tooele, Utah, have the potential for accidental releases that could escape installation boundaries and pose a threat to civilian populations. The US Army, in conjunction with the Federal Emergency Management Agency and other federal agencies, is committed to implement an emergency preparedness program that will significantly reduce the probability of adverse effects from such releases. This concept plan, which is but a part of a comprehensive ongoing effort, provides a framework for initiating such a program for the TEAD stockpile. This report develops information and methodologies that bear on two major decisions for such a program – determining emergency planning zones and selecting protective action strategies. These decisions are based on the hazards posed by the TEAD stockpile and its disposal. These hazards, in turn, are based largely on the distribution of potential accidental releases associated with interim storage and disposal activities and associated external events (e.g., earthquakes and airplane crashes), the distribution of natural features that can affect an agent release (topographical features and meteorological characteristics), and the distribution of people and resources (e.g., homes, schools, and hospitals) potentially affected by an accidental release. 22 refs., 9 figs., 12 tabs.

8373 (ORNL/TM–11095) **Emergency response concept plan for Newport Army Ammunition Plant and vicinity.** Carnes, S.A.; Sorensen, J.H.; Rogers, G.O.; Shumpert, B.L.; Miller, R.L.; Watson, A.P.; Chester, C.V. Oak Ridge National Lab., TN (USA). Oct 1989. 78p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004363. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The continued storage and disposal of the United States' unitary chemical stockpile, including that portion stored at Newport Army Ammunition Plant (NAAP) near Newport, Indiana, have the potential for accidental releases that could escape installation boundaries and pose a threat to civilian populations. The US Army, in conjunction with the Federal Emergency Management Agency and other federal agencies, is committed to implement an emergency preparedness program that will significantly reduce the probability of adverse effects from such releases. This concept plan, which is but a part of a comprehensive ongoing effort, provides a framework for initiating such a program for the NAAP stockpile. This report develops information and methodologies that bear on two major decisions for such a program – determining emergency planning zones and selecting protective action strategies. These decisions are based on the hazards posed by the NAAP stockpile and its disposal. These hazards, in turn, are based largely on the distribution of potential accidental releases associated with interim storage and

disposal activities and associated external events (e.g., earthquakes and airplane crashes), the distribution of natural features that can affect an agent release (topographical features and meteorological characteristics), and the distribution of people and resources (e.g., homes, schools, and hospitals) potentially affected by an accidental release. 22 refs., 9 figs., 12 tabs.

8374 (ORNL/TM–11096) **Emergency response concept plan for Aberdeen Proving Ground and vicinity.** Carnes, S.A.; Sorensen, J.H.; Rogers, G.O.; Shumpert, B.L.; Miller, R.L.; Watson, A.P.; Chester, C.V. Oak Ridge National Lab., TN (USA). Oct 1989. 78p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004364. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The continued storage and disposal of the United States unitary chemical stockpile, including that portion stored at Aberdeen Proving Ground (APG) near Edgewood, Maryland, have the potential for accidental releases that could escape installation boundaries and pose a threat to civilian populations. The US Army, in conjunction with the Federal Emergency Management Agency and other federal agencies is committed to implement an emergency preparedness program that will significantly reduce the probability of adverse effects from such releases. This concept plan, which is but a part of a comprehensive ongoing effort, provides a framework for initiating such a program for the APG stockpile. This report develops information and methodologies that bear on two major decisions for such a program – determining emergency planning zones and selecting protective action strategies. These decisions are based on the hazards posed by the APG stockpile and its disposal. These hazards, in turn, are based largely on the distribution of potential accidental releases associated with interim storage and disposal activities and associated external events (e.g., earthquakes and airplane crashes), the distribution of natural features that can affect an agent release (topographical features and meteorological characteristics), and the distribution of people and resources (e.g., homes, schools, and hospitals) potentially affected by an accidental release. 25 refs., 9 figs., 12 tabs.

8375 (ORNL/TM–11097) **Emergency response concept plan for Umatilla Depot Activity and vicinity.** Carnes, S.A.; Sorensen, J.H.; Rogers, G.O.; Shumpert, B.L.; Miller, R.L.; Watson, A.P.; Chester, C.V. Oak Ridge National Lab., TN (USA). Oct 1989. 78p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004365. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The continued storage and disposal of the United States' unitary chemical stockpile, including that portion stored at Umatilla Depot Activity (UMDA) near Hermiston, Oregon, have the potential for accidental releases that could escape installation boundaries and pose a threat to civilian populations. The US Army, in conjunction with the Federal Emergency Management Agency and other federal agencies, is committed to implement an emergency preparedness program that will significantly reduce the probability of adverse effects from such releases. This concept plan, which is but a part of a comprehensive ongoing effort, provides a framework for initiating such a program for the UMDA stockpile. This report develops information and methodologies that bear on two major decisions for such a program – determining emergency planning zones and selecting protective action strategies. These decisions are based on the hazards posed by the UMDA stockpile and its disposal. These hazards, in turn, are based largely on the distribution of potential accidental releases associated with interim storage and disposal activities and associated external events (e.g., earthquakes and airplane crashes), the distribution of natural features that can affect an agent release (topographical features and meteorological characteristics), and the distribution of people and resources (e.g., homes, schools, and hospitals) potentially affected by an accidental release.

8376 (ORNL/TM–11098) **Emergency response concept plan for Pueblo Depot Activity and vicinity.** Carnes, S.A.; Sorensen, J.H.; Rogers, G.O.; Shumpert, B.L.; Miller, R.L.; Watson, A.P.; Chester, C.V. Oak Ridge National Lab., TN (USA). Oct 1989. 110p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004366. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The continuous storage and disposal of the United States' unitary chemical stockpile, including that portion stored at Pueblo Depot Activity (PUDA) near Pueblo, Colorado, have the potential for accidental releases that could escape installation boundaries and pose a threat to civilian populations. The US Army, in conjunction with the Federal Emergency Management Agency and other federal agencies, is committed to implement an emergency preparedness program that will significantly reduce the probability of adverse effects from such releases. This concept plan, which is but a part of a comprehensive ongoing effort, provides a framework for initiating such a program for the PUDA stockpile. This report develops information and methodologies that bear on two major decisions for such a program – determining emergency planning zones and selecting protective action strategies. These decisions are based on the hazards posed by the PUDA stockpile and its disposal. These hazards, in turn, are based largely on the distribution of potential accidental releases associated with interim storage and disposal activities and associated external events (e.g., earthquakes and airplane crashes), the distribution of natural features that can affect an agent release (topographical features and meteorological characteristics), and the distribution of people and resources (e.g., homes, schools, and hospitals) potentially affected by an accidental release. 21 refs., 9 figs., 12 tabs.

8377 (ORNL/TM–11099) **Emergency response concept plan for Lexington-Blue Grass Army Depot and vicinity.** Carnes, S.A.; Sorensen, J.H.; Rogers, G.O.; Shumpert, B.L.; Miller, R.L.; Watson, A.P.; Chester, C.V. Oak Ridge National Lab., TN (USA). Oct 1989. 82p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004394. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The continued storage and disposal of the United States' unitary chemical stockpile, including that portion at Lexington-Blue Grass Army Depot (LBAD) near Richmond, Kentucky, have the potential for accidental releases that could escape installation boundaries and pose a threat to civilian populations. The US Army, in conjunction with the Federal Emergency Management Agency and other federal agencies, is committed to implement an emergency preparedness program that will significantly reduce the probability of adverse effects from such releases. This concept plan, which is but a part of a comprehensive ongoing effort, provides a framework for initiating such a program for the LBAD stockpile. This report develops information and methodologies that bear on two major decisions for such a program – determining emergency planning zones and selecting protective action strategies. These decisions are based on the hazards posed by the LBAD stockpile and its disposal. These hazards, in turn, are based largely on the distribution of potential accidental releases associated with interim storage and disposal activities and associated external events (e.g., earthquakes and airplane crashes), the distribution of natural features that can affect an agent release (topographical features and meteorological characteristics), and the distribution of people and resources (e.g., homes, schools, and hospitals) potentially affected by an accidental release. 9 figs., 13 tabs.

54 ENVIRONMENTAL SCIENCES

Refer also to citation(s) 8477

5401 Environmental Sciences, Atmospheric

Refer also to citation(s) 6803, 6812, 6896, 6928, 7472, 7473, 7474, 7499, 7500, 7501, 7502, 7503, 7504, 7505, 7508, 7580, 7592, 7599, 7678, 7679, 7876, 7879, 8108, 8179, 8183, 8184, 8431, 8579

8378 (BFR-D–10-1989) **CFC in refrigeration- and heat pump plants: Questionnaire list.** Berntsson, T. Swedish Council for Building Research, Stockholm (Sweden). 1989. 56p. Project BFR-871238-8. Order Number DE90728328. Available from NTIS (US Sales Only), PC A04/MF A01.

The increasing concern for the influence of chlorofluorosubstituted hydrocarbons on the ozone layer and future climatic changes has led to discussions and decisions nationally and internationally about successive decrease of the use of R11, R12, R113, R114, and

R115, i.e. fully substituted hydrocarbons. Although partially substituted hydrocarbons are generally believed to be much less dangerous, there are some doubts about their real environmental influence and their future use. The Executive Committee of IEA, Advanced Heat Pumps, decided at their last meeting (Paris, October 16, 1987) to initiate activities in this field. As a part of these activities it was decided to send out questionnaires to governmental authorities and agencies and research organizations active in this field in all IEA, Advanced Heat Pump countries. The aims with the questionnaire have been to collect information on attitudes towards various future solutions, ongoing and planned R and D activities and measuring facilities etc of interest in the countries. This report contains the results from the questionnares. The answers are presented under the headlines: * Possible measures in short and long terms. * Ongoing and planned R and D. * Available precious apparatus and experimental equipment. * Existing and planned experimental and demonstration plants. * Research cooperation. * Publications.

8379 (BFR-D–11-1989) **The CFC-seminar in Rome 30-31 May 1988: Proceedings.** Berntsson, T. Swedish Council for Building Research, Stockholm (Sweden). 1989. 334p. Project BFR-871238-8. (CONF-8805345–: IEA seminar on the CFC problem, Rome (Italy), 30-31 May 1988). Order Number DE90728329. Available from NTIS (US Sales Only), PC A15/MF A01.

The report contains the material presented at the seminar. Each IEA country presents their situation concerning regulations and legislation together with ongoing and planned R and D activities. Ten presentations were made of possible future measures to reduce pollution from freons. In particular alternative fluids were discussed. Some of the conclusions of the seminar: * The restrictions on the use of some CFC:s already taken internationally (Montreal), nationally or discussed will mean changes in refrigeration and heat pump equipment, which will have a worldwide enormous impact technically and economically. * For the necessary work international cooperation is crucial. It is important that too much duplicate work is avoided, that exchange of information between countries can be done at an early stage of R and D work. Joint efforts also means that results can be made available early. IEA is the appropriate organization for such international cooperation activities. * The need for exp/demo plants can not be exaggerated. This is probably the most important measure for the evaluation of various possible solutions. There is a need for such plants at least in the following areas; plants with new fluids, azeotropes and 'near'-azeotropes: non-azeotropic mixtures: plants with ammonia and flammable fluids: alternative compression cycles. Exp/demo plants are needed in both small, medium and large scale applications. They can be placed either in the field or in a laboratory, in which the behaviour of the whole system can be tested. Due to the importance of exp/demo plants projects for initiation of such plants must have high priority. Such projects can be done as parts of IEA annexes that will start in the CFC field.

8380 (BMU–1988-201) **Studies on the radioctive materials, sampling techniques and measurement in case of emissions into the ambient air from nuclear facilities and in the handling of radioactive materials.** Schriftenreihe Reaktorsicherheit und Strahlenschutz. Ergebnisberichte, Untersuchungen, Studien, Gutachten. Winkelmann, I.; Vogl, K. Bundesministerium fuer Umwelt, Naturschutz und Reaktorsicherheit, Bonn (Germany, F.R.); Bundesgesundheitsamt, Neuherberg (Germany, F.R.). Inst. fuer Strahlenhygiene. Mar 1987. 212p. (In German). Contract BMU St.Sch. 882. Available from Available from GRM Werbeberatung - Werbemittlung - PR, Eggenstein-Leopoldshafen, (Germany, F.R.).

The investigations described serve the purpose of deepening knowledge about the emission of radioactive substances from nuclear plants, of ensuring the updating of rules and guidelines for emission control, and of evaluating the radiation exposure of the population. The 5 subprojects are concerned with the preparation and testing of techniques for the determination of pure beta emitters, with the nuclide composition of short-lived radioactive aerosols and with the investigation for the sampling of radioactive aerosols and of radioactive iodine in the waste air of nuclear power plants, as well as with an investigation on the emission of alpha emitters in nuclear fuel processing factories and in the reprocessing plant of Karlsruhe, or with the investigation on the frequency, duration and amount of short-term emissions in nuclear power plants with LWRs. (DG).

8381 (BNL–43550) **Acid deposition.** Schwartz, S.E. Brookhaven National Lab., Upton, NY (USA). Nov 1989. 18p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-8908182–2: 9. session of the international seminars on nuclear war, Erice (Italy), 19-24 Aug 1989). Order Number DE90003959. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The acid deposition phenomenon is a well documented example of the influence of industrial activities on atmospheric composition and precipitation composition. This phenomenon consists of emissions of sulfur and nitrogen oxides into the atmosphere, largely from fossil-fueled combustion, followed by transport, chemical transformation, and deposition to the surface. This deposition consists principally of deposition of sulfuric and nitric acids in precipitation (wet deposition) and deposition of gaseous SO_2, NO_2, and HNO_3 in the absence of precipitation (dry deposition). The acid deposition phenomenon is widely held to be responsible for deleterious effects on ecological systems, structural and ornamental materials, and visibility in the atmosphere. Because of the density of emission sources in eastern North America, it is not yet possible to specify precisely the contribution to deposition at particular receptor sites to particulate emission sources. Present understanding of atmosphere transport velocities and rates of transformation and deposition processes suggest mean source-receptor distances of 500 to 1500 km. Regional emission densities in the Northeast United States substantially exceed standards that have been suggested to protect sensitive ecosystems. Recognition of the properties of the acid deposition phenomenon is explicitly noted in prospective legislation in the United States. 47 refs., 3 figs., 1 tab.

8382 (CANWEC–CE-02832, pp. 16) **Environmental control measures in duth stations: Report 2.3.7.** . Kooij, J. van der (Physcial Planning and Environmental Affairs (Netherlands)); Brugghen, F.W. van der. Canadian National Committee, World Energy Conference, Ottawa, ON (Canada). 1989. (CONF-890901–: 14. world energy conference, Montreal (Canada), 17-22 Sep 1989; CE–02832). In *Energy for tomorrow. Division 2: Energy and the environment: Session 2.3: Environmental concens: The role of technology.* Available from Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN.

Technology and policy initiatives used to control sulfur dioxide and nitrogen oxide emmissions are the focus of this presentation. Statistics of the emissions of sulphur dioxide and other pollutants are given from 1980 onwards. Dutch legislation and regulations aimed at controlling acid emissions are described in some detail. The emphasis of technological improvement has been on coal- and gas-fired installations. Major projects include combustion modifications during conversion of three tangentially fired boilers from gas/oil to coal and a demonstration project of advanced low NO_x technology in a front wall fired boiler. In ten gas-fired power stations with an equivalent capacity of 3653 MW a gasturbine was installed in front of the main cycle in order to improve the thermal efficiency and to reduce the NO_x-emission. Oil-fired boiler and flue gas denitrificaton has been demonstrated in 50% of the flue gases of a 130 MW coal fired power station. The emission of particulates was reduced by the use of high efficiency electrostatic precipitators. The emissions were further reduced by the use of wet flue gas desulfurization (FGD) systems. Dutch electricity supply companies have set up a company with the task to market the slag, fly ash and FGD by-products and to develop new applications. some detail.

8383 (CPS–40-11/14-1989E, pp. 3A23-3A42) **The North Slope Borough's experiences with incineration.** Thomas, J.E. (Alaska Dept. of Environmental Conservation, Fairbanks, AK (USA)); Coutts, J. Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422–: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG–89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available

from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

The North Slope Borough operates the largest incinerator in Alaska at Prudhoe Bay. Although the incinerator serves the oil patch industrial area, the solid waste contains a large fraction of shop and camp waste. The incinerator is a BASIC Model 5000 with 2 cascading hearths, an auxiliary burner, twin cyclonic section afterburners, waterwall construction, and a boiler section. A 2-field electrostatic precipitator was retrofitted to the incinerator in 1987. Recovered heat is used to heat the solid waste plant building and an adjacent borough office/residential complex. The incinerator operates under an Air Quality Control Permit issued by the Alaska Department of Environmental Conservation. In addition to following the Air Quality Control Regulations, the permit requires the incinerator to meet a 100 ppM CO standard and a minimum combustion temperature of 1500 degrees F. Experience with the entire operation from trash collection to flue gas monitoring indicates the difficulty of operating in the Arctic. At the time of this writing, the system is still being fine tuned to get it to operate in an optimum manner. Reducing the amount of excess air and using a cheaper fuel should allow the CO and temperature standards to be met at a lower operating cost. 3 figs., 4 tabs.

8384 (DTH-LET-RE–88-5) **Total emission of CO, HC, NOx and particles from the cars in Denmark: Prognosis from 1980 to 2010.** Nielsen, A.S.; Pedersen, P.H.; Schramm, J.; Sorenson, S.C. Danmarks Tekniske Hoejskole, Lyngby (Denmark). Lab. for Energiteknik. 1988. 44p. (In Danish). Order Number DE90728126. Available from NTIS (US Sales Only), PC A03/MF A01.

The total emission of carbon monixide, hydrocarbons, nitrogen oxides, and particulates from all Danish cars in the period 1980 to 2010 is calculated. Comparatively detailed calculation models are applied. The models build on different assumptions on use and condition of the various catagories of vehicles. A comparison is made of the consequiences of (1) Retaining the present requirements (2) Introducing requirements from the European Communities (3) Introducing the American rquirements. At present, the requirements regarding CO-emission involve a decrease from 582.000 tons in 1986 to 570.000 tons in 2010 (2%). If the EEC requirements are introduced the CO-emission involved decrease to 260.000 tons in 2010 (55%). If the American requriements are introduced the CO-emission would decrease to 110.000 in 2010 (81%). The HC-emission increases, if the present requirements are retained, from 59.000 tons in 1986 to 80.000 tons in 2010 (36%). If the EEC requirements are introduced the HC-emission decrease to 58.000 tons in 2010 (2%). If the American requirements are introduced the HC-emission decrease to 15.000 tons in 2010 (75%). The NOx-emission would increase form 81.000 tons in 1986 to 117.000 in 2010 if the present requirements are retained. If the EEC requirements are introduced the NOx-emission would increase to 97.000 tons in 2010 (20%). If the American requirements are introduced the NOx-emission will decrease to 63.000 tons in 2010 (22%). The particulate-emission will incrase from 4.000 tons in 1986 to 5.900 tons in 2010 (48%) if the present requirements are retained. If the EEC requirements are introduced the particulate-emission will increase to 4.500 tons (13%). If the American requirements are introduced the particulate-emission will decrease to 2.300 tons (43% decrease). (AB).

8385 (EPRI-GS–6307-Vol.2, pp. 7.1-7.20) **An experimental and theoretical study of the fundamentals of the SO_2/lime reaction at high temperatures.** Milne, C.R. (Univ. of Utah, Salt Lake City (USA)); Pershing, D.W.; Kirchgessner, D.A. Electric Power Research Inst., Palo Alto, CA (USA); Radian Corp., Research Triangle Park, NC (USA). Apr 1989. (CONF-881028–Vol.2: 1. combined flue gas desulfurization and dry SO_2 control symposium, St. Louis, MO (USA), 25-28 Oct 1988). In *Proceedings: First combined flue gas desulfurization and dry SO_2 control symposium.* Order Number DE89010591. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

An experimental and theoretical study of the SO_2/lime reaction is described. The experimental portion focuses on elucidating the differences in reactivity between Linwood calcium hydrate and Linwood calcium carbonate at high temperatures (1250 to 1450 K) and at short times (30 ms). The contributions of particle size effects to reactivity differences are examined using air classified sorbents. The impact of temperature and SO_2 partial pressure on sorbent utilization is also determined. The experimental results indicate that the primary reason for the superior reactivity of hydrates relative to carbonates is the smaller particle diameter of the hydrates. Based on the experimental results, a comprehensive, mathematical SO_2-sorbent reaction model was developed which includes simultaneous calcination, sulfation, and sintering. The model is unique relative to previous efforts because it begins with the raw material and calculates subsequent surface area and pore size properties for the simultaneously calcining and sulfating particles. This paper has been reviewed in accordance with the US Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication.

8386 (EPRI-GS–6307-Vol.2 U.19-U.38) **SO_2 capture in a coal-fueled gas turbine system.** Johnson, S.A. (PSI Technology Co., Andover, MA (USA)); Walkauskas, L.P.; Morency, J.R. Electric Power Research Inst., Palo Alto, CA (USA); Radian Corp., Research Triangle Park, NC (USA). Apr 1989. DOE Contract AC21-86MC23168. (CONF-881028–Vol.2: 1. combined flue gas desulfurization and dry SO_2 control symposium, St. Louis, MO (USA), 25-28 Oct 1988). In *Proceedings: First combined flue gas desulfurization and dry SO_2 control symposium.* Order Number DE89010591. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

Sulfur dioxide capture at short residence times was investigated in an entrained flow reactor to determine the efficacy of dry sorbent injection in the combustor as a means of reducing SO_2 emissions in coal fired gas turbines. The sorbents examined were commercial grade hydrated limes, calcitic and dolomitic. Effects of temperature, SO_2 concentration and residence time on SO_2 capture were measured for each sorbent. Results show significant SO_2 capture at atmospheric pressure for residence times { >=} 20 ms, with capture at 1100°C and (SO_2) = 1000 ppm being 37 and 65% for calcitic and dolomitic sorbents, respectively. The rather steep temperature dependence over the range of 900 to 1100°c indicates the importance of the point of injection on sorbent performance in practical systems. If added sorbent does not exacerbate deposition of solids on turbine blades or combustor walls, dry sorbent injection can be an effective means of removing SO_2 in coal fired gas turbine systems.

8387 (EPRI-GS–6307-Vol.2 U.45-U.59) **Combined SO_x/NO_x removal in a high-sulfur spray-dryer/fabric-filter system.** Livengood, C.D. (Argonne National Lab., IL (USA)); Huang, H.S.; Allen, J.W.; Farber, P.S. Electric Power Research Inst., Palo Alto, CA (USA); Radian Corp., Research Triangle Park, NC (USA). Apr 1989. DOE Contract W-31-109-ENG-38. (CONF-881028–Vol.2: 1. combined flue gas desulfurization and dry SO_2 control symposium, St. Louis, MO (USA), 25-28 Oct 1988). In *Proceedings: First combined flue gas desulfurization and dry SO_2 control symposium.* Order Number DE89010591. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

Argonne National Laboratory (ANL) has been conducting research on combined nitrogen oxides (NO_x) and sulfur dioxide (SO_2) control since 1981. Technologies applicable to both retrofit and new installations have been investigated, with particular emphasis on applications involving high-sulfur coal. A major portion of this program has been centered around the spray-dryer/fabric-filter system that provides flue-gas cleanup (FGC) for Argonne's largest, coal-fired boiler. This was the first FGC system of its type to be installed and continuously operated on high-sulfur coal in the US. Over the last six years, Argonne's research has established that the technology is both effective and economical for control of SO_2 in that application. Under the combined SO_x/NO_x research program, Argonne conducted two series of field tests on the spray-dryer FGC system. The conditions for the tests were selected on the basis of previous work by Niro Atomizer (using the ANL system), laboratory research at ANL, and intermediate-scale tests at the Pittsburgh Energy Technology Center (PETC). Both changes in process operating conditions and addition of caustic soda (NaOH) to the lime slurry were

employed. The results indicated that, under certain operating conditions, it is possible to achieve significant levels of combined control. The addition of NaOH was not essential, but did enhance removal of NO_x. Also, higher levels of SO_2 in the inlet flue gas were found to be beneficial, and changes in particle characteristics that developed in the drying process were found to play a role that has implications for other technologies based on dry sorbents.

8388 (EPRI-GS–6423-Vol.1, pp. 1.1-1.7) **Innovative clean coal technology NO_x control technology.** Temchin, J. (Dept. of Energy, Washington, DC (USA)); Feibus, H. Electric Power Research Inst., Palo Alto, CA (USA). Jul 1989. (CONF-890318–Vol.1: Joint symposium on stationary combustion nitrogen oxide control, San Francisco, CA (USA), 6-9 Mar 1989). In *1989 symposium on stationary combustion nitrogen oxide control. Volume 1.* Order Number DE89016351. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

The recent selections of the Innovative Clean Coal Technology program were made on September 27, 1988, and consisted of 16 projects. A number of the projects involved techniques for controlling NO_x – i.e., from coal-fired power plants. These projects will be described in detail. Three of the projects represent innovative combustion control techniques and one involves catalytic reduction. In addition, five of the selected projects involve a combination of SO_2 and NO_x control – two employ flue gas cleanup techniques and three employ repowering techniques.

8389 (EPRI-GS–6423-Vol.1, pp. 1.55-1.72) **Measurement of N_2O from combustion sources.** Muzio, L.J. (Fossil Energy Research Corp., Laguna Hills, CA (USA)); Teague, M.E.; Montgomery, T.A.; Samuelsen, G.S.; Kramlich, J.C.; Lyon, R.K. Electric Power Research Inst., Palo Alto, CA (USA). Jul 1989. DOE Contract AC22-84PC70771. (CONF-890318–Vol.1: Joint symposium on stationary combustion nitrogen oxide control, San Francisco, CA (USA), 6-9 Mar 1989). In *1989 symposium on stationary combustion nitrogen oxide control. Volume 1.* Order Number DE89016351. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

N_2O emissions from fossil combustion have been reported to be 25-40% of the NO_x levels. At these levels, fossil fuels have been suggested to be a major anthropogenic source of N_2O. Recent tests have shown these measurements to be in error, the N_2O being formed by reaction between NO_x, SO_2, and H_2O in the sample containers. Time resolved measurements of gas samples stored in Tedlar bags, supported by chemical kinetic calculations, indicate that the majority of N_2O forms over a time period of 6 hours and depends on the amount of SO_2 present, initial NO level, and amount of water present. A continuous infrared analyzer, suitable for characterizing N_2O from combustion sources, has been developed. The analyzer has been used to perform continuous on line N_2O measurements at nine utility boilers (pulverized coal and oil fired). The measurements indicate that the N_2O levels are generally less than 5 ppm and are not related to the NO_x levels in the flue gas.

8390 (EPRI-GS–6519, pp. 6.1-6.15) **Evaluating combined SO_2/NO_x processes.** Rubin, E.S. (Carnegie Mellon Univ., Pittsburgh, PA (USA)); Salmento, J.S.; Frey, H.C. Electric Power Research Inst., Palo Alto, CA (USA). Sep 1989. DOE Contract AC22-87PC79864. (CONF-880326–: 4. symposium on integrated environmental control, Washington, DC (USA), 2-4 Mar 1988). In *Proceedings: Fourth symposium on integrated environmental control.* Order Number DE90000517. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

A probabilistic modeling framework is described for evaluating combined SO_2/NO_x removal systems and other emerging technologies for integrated environmental control that offer the potential for lower cost relative to conventional systems. A case study is presented in which the performance and cost of the DOE fluidized bed copper oxide process for combined SO_2/NO_x removal is compared to a baseline power plant design using a wet flue gas desulfurization system and selective catalytic reduction to achieve high levels of pollutant removal using a high sulfur (4.4%S as fired) midwestern coal. Integrated system designs that employ physical coal cleaning in conjunction with post-combustion controls also are considered in the analysis. The results indicate that the combined SO_2/NO_x removal systems offer the potential for significant cost savings when combined with coal cleaning to achieve lower coal sulfur levels. The likelihood of future reductions in the cost of conventional technology was seen to be an important factor in evaluating potential benefits from advanced process designs.

8391 (ETDE-mf–0732339) **Separation efficiency and limits of a MULTIWIR rotational washer. Final report.** Leschonski, K. Technische Univ. Clausthal, Clausthal-Zellerfeld (Germany, F.R.). Inst. fuer Mechanische Verfahrenstechnik und Umweltverfahrenstechnik; Deutsche Forschungsgemeinschaft, Bonn (Germany, F.R.). [1989]. 17p. (In German). Contract DFG Le 410/14-1. Order Number DE90732339. Available from NTIS (US Sales Only), PC A03/MF A01.

Water and energy comsumption constitute, besides the separation effect, the main aspects of interest in particle separation with wet separators. Energy consumption increases exponentially as the size of the particles to be separated decreases. The so-called MULTIWIR packings ("multi-effect packings") were developed by means of investigations of flow fields, pressure loss and separation effect. These packings permit a cross-flow of gas in space in the form of thin gas jets. Under the impact of centrifugal forces, droplets and solid particles from the rotating gas jets are deposited on the surfaces of the packing elements. In the course of work on the project, a dust separator was designed, manufactured and tested on the basis of this principle. (EF).

8392 (ETDE-mf–0732397) **An adaptive dispersion model for the prediction of pollutant concentrations for the urban area of Berlin.** Sprenger, D. Technische Univ. Berlin (Germany, F.R.). Fachbereich Verfahrenstechnik. 6 Jul 1988. 182p. (In German). Order Number DE90732397. Available from NTIS (US Sales Only), PC A09/MF A01.

In this study, methods of the filter theory and system identification for the adaptation of an urban spreading model were applied. The efficiency of these methods could be proved on the basis of simulations and measured immission values from the urban area of Berlin. It could be demonstrated in particular that it is possible to make a combined estimation of the source strengths and the vertical function for the vertical diffusion in an advection-diffusion equation. The results of the forecasts up to three hours proved that the adaptive spreading model predicts very well the time of the beginning of increased pollution. This model, however, tends to overestimate very much the immission levels. Therefore at the present development stage, the adaptive spreading model should have indicator function for smog situations. (orig./KW).

8393 (GKSS–89/E/24) **Calculation of initial conditions for the material transport in mesoscale circulation models.** Bigalke, K. (Hamburg Univ. (Germany, F.R.). Meteorologisches Inst.); Schatzmann, M. GKSS-Forschungszentrum Geesthacht G.m.b.H., Geesthacht-Tesperhude (Germany, F.R.). 1989. 232p. (In German). Available from Available from GKSS-Forschungszentrum Geesthacht GmbH, Geesthacht-Tesperhude (Germany, F.R.).

A numerical model is developed for predicting the dispersion of pollutants emitted from a stack into the atmosphere. The model consists of two parts: (1) an integral model utilized to simulate the jet-like near field of the dispersing plume, and (2) a diffusion model for the subsequent phase which is dominated by atmospheric turbulence. The two submodels are linked to each other. The coupled model provides initial conditions for the simulation of pollutant transport in meso-scale grid models. (orig.) With 26 figs.

8394 (INIS-mf–12033 vp) **Does the world's climate change?. On the carbon dioxide problem of fossil energy systems.** Schoenwiese, C. (Frankfurt Univ. (Germany, F.R.). Inst. fuer Meteorologie und Geophysik). Vereinigung Deutscher Elektrizitaetswerke e.V. (VDEW), Frankfurt am Main (Germany, F.R.). 1988. (In German). (CONF-8812104–: VDEW symposium: perspectives of electricity supply, Frankfurt am Main (Germany, F.R.), 5-7 Dec 1988). In *Perspectives of electricity supply.* Order Number DE90729204. Available from NTIS (US Sales Only), PC A08/MF A01; NTIS (US Sales Only), PC A08/MF A01.

A survey is given on the carbon dioxide problem for the climate caused by the consumption of fossil fuels. The carbon dioxide content of the atmosphere has increased from about 280 ppm at the beginning of the 19th century to about 350 ppm in the year 1988. In the case of a doubling, a rise of the global average temperature of

about 1.5-4.5 degrees is to be expected according to climate models. Further trace gases are involved in the greenhouse effect, which are released into the atmosphere partly by human activities. Observations of the temperature of the last 150 years indicate a warming of about 0.5-1 degree, which, however, cannot be clearly attributed to the greenhouse effect. Precautionary measures are necessary to reduce the global consumption of fossil energies. (KW).

8395 (Juel–2290) **Comparison of chloride-, nitrate-, sulfate-, sodium-, lead- and copper-ion concentration changes in rain water of Juelich/Stolberg: Discussion of fundamental relationships and common causes.** Wagner, F. Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Inst. fuer Angewandte Physikalische Chemie; Technische Hochschule Aachen (Germany, F.R.). Jul 1989. 172p. (In German). Order Number DE90732539. Available from NTIS (US Sales Only), PC A08/MF A01.

The report is based on data about the concentration of Cl^-, NO^-_3, SO^{2-}_4, Na^+, NH^+_4, Zn^{2+}, Cd^{2+}, Pb^{2+} and Cu^{2+} in rain collected on the ground. Samples were taken monthly from January 1983 to March 1985 in Juelich and Stolberg, in addition, for single rainfalls in Juelich in spring 1984. As to the monthly data, it was found, firstly that the Na^+ and Cl^- concentrations were linearly correlated, and secondly, that there was a linear correlation between the concentrations of Cl^-, NO^-_3, SO^{2-}_4, NH^+_4, Zn^{2+}, Cd^{2+}, Pb^{2+} and Cu^{2+}. This suggested to distinguish between marine and industrial concentrations. The correlations were due to meteorological influences rather than to the emitting sources as long as source and collector were not very close together. The single rainfalls started with concentrations due to the origin of the air. The concentrations of all ions under consideration changed in a similar way during the rainfalls. It was not possible to take samples in clouds. Nevertheless a box model, introduced in this paper, implies that the ions in the rain water are due to rainout rather to washout. Chemical reactions and distant sources about 10 km away need not be considered. There are two reasons for the decrease of the concentrations during a rainfall. Firstly, the atmosphere within the cloud is cleaned by the fall of rain, the decrease of concentrations depending on the intensity of the rain, the thickness of the cloud and the liquid water content of the cloud. Secondly, the atmosphere beneath the cloud is cleaned as the ions are carried into the cloud by convections and eddy diffusion. Here the decrease depends on the vertical velocity and on the distance between the ground and the lower boundary of the cloud. (orig./RB).

8396 (KVM–21) **KVM report from the activities during 1988.** KVM, the Joint Committee of Power and Heating Producers on Environmental Issues, Stockholm (Sweden). Mar 1989. 24p. (In Swedish). Order Number DE90728269. Available from NTIS (US Sales Only), PC A03/MF A01.

One of the main objects of the KVM which is the Joint Committee of Power and Heating Producers on Environmental Issues is to establish improved contact with all parties. The report deals with two items, namely the impact of greenhouse effect warming and acidification of forest soils.

8397 (LMOSC–89-03677) **Assessment of light duty gasoline vehicle emissions inspection and maintenance program options for the lower mainland area.** Lower Mainland Oxidants Steering Committee, BC (Canada). Mar 1989. 271p. (MICROLOG–89-03677). Available from PC British Columbia Legislative Library, Government Documents Division, Parliament Buildings, Victoria, BC, CAN V8V 1X4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

Elevated levels of ozone, a measure for photochemical oxidants, have been experienced in the lower mainland of British Columbia in recent years. As part of the framework for ozone control strategies, it was recommended that the feasibility of a motor vehicle emission inspection and maintenance (I/M) program be examined. Subsequently, a task force was set up to identify I/M program options, particulary those where private industry plays a key role, and to provide an analysis of the anticipated benefits and preliminary costs associated with each option. The findings of the investigation are presented in this document. It provides brief background information on emissions of photochemical oxidant precursor contaminants and on the relevant air quality situation in the area. The characteristics of the motor vehicle emissions, the types of available emission control technology, and the potential increase in emissions due to malmaintenance, tampering, and misfuelling are also discussed. A summary of all existing and proposed I/M programs in the USA is provided, along with descriptions of the major features of these programs. The potential emission reductions due to the introduction of new federal emission standards, for 1988 and later model years, and several types of I/M programs have also been estimated. On the basis of the above, an I/M program for the area has been outlined, and recommendations made for several supplementary measures as well as further activities for the final design of the program. 136 refs., 23 figs., 51 tabs.

8398 (NEI-DK–231) **Air pollution by mutagenic substances in Copenhagen and the surrounding area.** Arbejdsrapport fra Miljoestyrelsen, 11. Ostenfeldt, N. (Instituttet for Toksikologi, Levnedsmiddelstyrelsen (DK)). Miljoestyrelsen, Copenhagen (Denmark). 1989. 146p. (In Danish). Order Number DE90728078. Available from NTIS (US Sales Only), PC A07/MF A01.

The aim of the project was, after an investigation of the suitability of the experimental method for determining the mutagenic activity of organic extracts from outside-air samples, to discover the niveau and time variations of the mutagenic activity in the air over especially interesting localities, where there are, for example, heavy traffic or industry, power plants, etc. It was also important to find the main sources of mutagenic activity. This was attempted by ensuring that test samples were taken from the same place and at the same time as those taken in relation to the air quality programme covering the whole of Denmark. In the aforementioned programme the pollution parameters of basic chemical substances from specific sources are determined. These measurement results were compared with the niveau of mutagenic activity in a statistic analysis. At the same time an analysis of the polynuclear aromatic hydrocarbon occurence in selected air samples has been carried out, as this can provide a basis for the determination of the main sources of air pollution. It was attempted to relate mutagenic activity to the major groups of chemical substances, partly on the basis of the PAH analyses, and partly by the utilization of various methods for the determination mutagenicity. (AB) 74 refs.

8399 (ORNL–6536) **ORNL long-range environmental and waste management plan: Program overview and summary.** Baldwin, J.S.; Bates, L.D.; Brown, C.H.; Easterday, C.A.; Hill, L.G.; Kendrick, C.M.; McNeese, L.E.; Myrick, T.E.; Payne, T.L.; Pepper, C.E. Oak Ridge National Lab., TN (USA). Sep 1989. 61p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC05-84OR21400. Order Number DE90004403. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This report, the ORNL Long-Range Environmental and Waste Management Plan, is the annual update in a series begun in fiscal year 1985. Its primary purpose is to provide a thorough and systematic planning document to reflect the continuing process of site assessment, strategy development, and planning for the current and long-term control of environmental issues, waste management practices, and remedial action requirements. The document also provides an estimate of the resources required to implement the current plan. This document is not intended to be a budget document; it is, however, intended to provide guidance to both Martin Marietta Energy Systems, Inc., and the US Department of Energy (DOE) Management as to the near order of magnitude of the resources (primarily funding requirements) and the time frame required to execute the strategy in the present revision of the plan. As with any document of this nature, the near-term (1 to 3 years) part of the plan is a pragmatic assessment of the current program and ongoing capital projects and reflects the efforts perceived to be necessary to comply with all current state and federal regulations and DOE orders. It also should be in general agreement with current budget (funding) requests and obligations for these immediate years. Beyond the immediate time frame, the document reflects the strategy and the project and funding estimates as a snapshot at the time of publication.

8400 (ORNL–6552) **Environmental, health, and CFC [chlorofluorocarbons] substitution aspects of the ozone depletion issue.** Van Hook, R.I.; Fairchild, P.D.; Fulkerson, W.; Perry, A.M.; Regan, J.D.; Taylor, G.E. Oak Ridge National Lab., TN (USA). Nov

1989. 47p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004404. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

In 1974 chlorofluorocarbons (CFCs) were identified as playing a major role in depleting the stratospheric ozone layer, a process which could potentially result in increasing levels of UV(B) radiation. Substantial progress has been made in the ensuing years, especially after the surprising discovery of the ozone hole in Antarctica in 1984. Investigation of this hole's development has led to improved understanding of heterogeneous gas-solid phase reaction kinetics occurring in the stratosphere, but there are still uncertainties in the developing theory of ozone depletion. The connection betwen global CFC production and stratospheric ozone depletion is plainly evident. It is also evident that the long atmospheric lifetimes of these synthetic organic chemicals lead to decadal time frames between the response on CFC emissions and the reaction of chlorine with stratospheric ozone molecules. It is generally accepted that complete CFC phaseout is required to alleviate this situation; however, even if emissions could be reduced to zero immediately, ozone depletion would continue for many decades although at a declining rate. A critical question to be addressed is that of the actual timing of the CFC phaseout. It appears to us that the decision to phase out CFCs completely (i.e., a 90% or 100% phaseout vs 50% phaseout as called for in the Montreal Protocol) is much more important than whether the phaseout occurs within the next 5 years or the next 10 years. This question is particularly important relative to the availability of tested chemical and nonchemical CFC substitutes for refrigeration and insulation purposes. 24 refs., 4 figs., 3 tabs.

8401 (ORNL/FTR–3486) **[Acid rain in Asia]: Foreign trip report, November 10, 1989–November 18, 1989.** Dale, V.H. Oak Ridge National Lab., TN (USA). 27 Nov 1989. 13p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90003591. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This workshop was organized by Argonne National Laboratory and the Asian Institute of Technology. The objectives of the workshop were to (1) discuss observed and potential regional acidification in Asia, and (2) develop a research strategy by which the pertinent information could be gathered and analyzed and critical persons could be contacted regarding regional impacts of acidification in Asia.

8402 (ORNL/TM–11303) **Minutes of the workshop on offsite release criteria for contaminated materials.** Singh, S.P.N. Oak Ridge National Lab., TN (USA). Nov 1989. 100p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. Order Number DE90004396. Available from NTIS, PC A06/MF A01; OSTI; INIS; GPO Dep.

A one and one-half-day workshop was held May 2-3, 1989, at the Pollard Auditorium in Oak Ridge, Tennessee, with the objective of formulating a strategy for developing reasonable and uniform criteria for releasing radioactively contaminated materials from the US Department of Energy (DOE) sites. This report contains the minutes of the workshop. At the conclusion of the workshop, a plan was formulated to facilitate the development of the above-mentioned offsite release criteria.

8403 (SAND–89-1338C) **A qualitative architecture for understanding policy responses to global change.** Engi, D. Sandia National Labs., Albuquerque, NM (USA). [1989]. 8p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-891210–2: 9. Miami international congress on energy and environment, Miami Beach, FL (USA), 11-13 Dec 1989). Order Number DE90003936. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

This paper presents an architecture which will provide qualitative clarification of the principal cause-and-effect relationships among various policy options and the resulting impacts on anthropogenic greenhouse gas emissions. A fundamental product of analyzing the Global Change issue in the context of this architecture is the conceptual identification and internalization of conventionally external costs. The robust policy portfolios which evolve from this analysis will, by design, recognize the international dimension and be driven by adaptive incrementalism in order to avoid ill-conditioned and/or major, short-term, infrastructural changes to our energy systems. 6 refs., 3 figs.

8404 (SNV–3578) **Emissions from heavy diesel vehicles: Measurements 1980-1988.** Laveskog, A. (Statens Naturvaardsverk, Nykoeping (SE). Bilavgaslaboratorieenheten). National Swedish Environmental Protection Board, Solna (Sweden). Mar 1989. 33p. (In Swedish). Order Number DE90728300. Available from NTIS (US Sales Only), PC A03/MF A01.

During the period 1980-1988, emission measurements have been carried out on heavy duty vehicles for investigation of different fuels and exhaust gas treatments. In all cases there has been reference tests carried out using standard diesel fuel without control devices as catalysts and particulate emission traps. Also tests have been performed to map the emissions from the Swedish heavy duty vehicles. All tests performed according to the 13 mode test cycle are reported. About 350 tests have been performed on 128 vehicles. The results are presented as mean values mostly in diagrams. Heavy buses, heavy trucks and medium sized trucks intended for distribution in cities are reported in separate groups. There has been no emission rules for the type of vehicles studied and thus the changes in emissions and fuel consumption mostly have been a result of technical development and the strive for lower fuel consumption. Emissions of CO and HC has been considerably lowered but for NO_x no change can be seen for medium size trucks and for the heavy duty trucks an increase is seen. For the buses however, a decrease in NO_x emission can be seen, probably due to the demand from city traffic companies to have buses with low emissions.

8405 (SNV–3582) **Exhaust gas discharge from light-duty trucks.** Bjoerkman, E. (Statens Naturvaardsverk, Nykoeping (SE). Bilavgaslab.); Grigoriadis, V.; Graegg, K.; Egebaeck, K.E.; Westerholm, R.; Rannung, U. National Swedish Environmental Protection Board, Solna (Sweden). Jun 1989. 64p. (In Swedish). Order Number DE90728301. Available from NTIS (US Sales Only), PC A04/MF A01.

Nine trucks were mapped with regard to discharge of pollutants. 7 were gasoline- and 2 diesel-powered, 1 with indirect and 1 with direct injection. Carbon monoxide, hydrocarbons, and nitrogen oxides were measured. In addition sampling were done for analysis of polycyclic aromatic hydrocarbons (particle and gas phase) and of aldehydes. Biological tests were done in particle as well as in gas phase. The report presents the results in comparisons between lead-bearing and lead-free petrol, small diesel vehicles with precombustion chamber engine and with direct injection engine, petrol operation and diesel operation, hot start and cold start, and high and low load. 21 illustrations, 14 tables.

8406 (STEV-FBT–89-32) **Limitation of NO_x emissions from fluidized-bed combustion.** Aamand, L.E. (Chalmers Univ. of Tech., Goeteborg (SE). Dept of Energy Conversion); Leckner, B. Statens Energiverk, Stockholm (Sweden). Oct 1988. 14p. (In Swedish). Project STEV-276-201. (CONF-8810456–1: 1. Nordic conference on sulfur dioxide and nitrogen oxide reduction in relation to combustion of solid fuels, Lyngby (Denmark), 17-18 Oct 1988). Order Number DE90728283. Available from NTIS (US Sales Only), PC A03/MF A01.

The report presents a strategy for limitation of nitrogen oxide emissions based on the present knowledge of nitrogen oxide formation and mitigation. The application of the strategy in the various research programs is also accounted for, together with the most important results from the last heating period. 13 illustrations, 21 refs.

8407 (STEV-FBT–89-33) **N_2O-emissions from fluidized bed combustion.** Andersson, S. (Chalmers Univ. of Tech., Goeteborg (Sweden). Dept. of Energy Conversion); Aamand, L.E.; Leckner, B. Statens Energiverk, Stockholm (Sweden). 1988. 16p. Project STEV-276-201. (CONF-8811294–1: IEA AFBC technical meeting, Amsterdam (Netherlands), 18-20 Nov 1988). Order Number DE90728290. Available from NTIS (US Sales Only), PC A03/MF A01.

Nitrous oxide, N_2O, is formed during combustion. In flames the N_2O is removed because of the fast destruction at high temperatures. At the temperatures of fluidized bed combustion the destruction is much slower and N_2O will leave the system, normally

at a concentration of 50-200 ppm when burning coal. Using the results of the preliminary model in a CFB, it can be assumed that: * N_2O is formed from char nitrogen in the bottom bed because of reactions in the pores of the particle. * Only some N_2O is formed when NO is reduced during its journey up through the combustion chamber. * N_2O is formed from HCN. This is a slow process (taking seconds) and it therefore takes place principally above the bottom bed. 10 illustr., 9 refs.

8408 (STEV-FBT–89-34) **The effect of reducing conditions on sulphur capture - A comparison of three boilers.** Lyngfelt, A. (Chalmers Univ. of Tech., Goeteborg (SE). Dept. of Energy Conversion); Aamand, L.E.; Leckner, B. Statens Energiverk, Stockholm (Sweden). 1988. 12p. Project STEV-276-201. (CONF-881201–1: 4. international fluidised combustion conference, London (UK), 14-15 Dec 1988). Order Number DE90728284. Available from NTIS (US Sales Only), PC A03/MF A01.

The temperature dependence of sulphur capture with limestone in fluidised bed boilers (FBB's) is studied. The decrease in sulphur capture performance at higher temperatures is explained by local depletion of oxygen resulting in reducing zones. In these zones $CaSO_4$ is reductively decomposed whereby SO_2 is released. Measurements from two circulating and one stationary, commercial-type FBB's are compared in order to demonstrate differences in the temperature dependence of sulphur capture. The lime in the particle phase of a stationary FBB and that in a circulating FBB are subjected to different chemical conditions and the boilers behave differently with respect to sulphur capture. However the two circulating FBB's also differ from each other which puts an emphasis on design and operating conditions.

8409 (STEV-FBT–89-35) **NO_x reduction by means of additives in high pressure reactors.** Carlsson, R. (Chalmers Univ. of Tech., Goeteborg (SE). Dept. of Energy Conversion); Ivarsson, E.L.; Wallman, H. Statens Energiverk, Stockholm (Sweden); Chalmers Univ. of Tech., Goeteborg (Sweden). Dept. of Energy Conversion. Dec 1988. 36p. (In Swedish). Project STEV-276-362. (CTH-IE-A–88-176). Order Number DE90728285. Available from NTIS (US Sales Only), PC A03/MF A01.

NO_x reduction by means of ammonia and other reducing agents was studied in a pressurized research facility (PFBC). The testing comprised the reduction process dependence on pressure, temperature, bed size, material, reducing agent, duration, and stoichiometry. As the most important result it was established that high pressure resulted in good NO_x reduction.

8410 (STEV-FBT–89-36) **Reaction between calcium carbonate and sulfur dioxide: Final report.** Tullin, C. (Chalmers Univ. of Tech., Goeteborg (SE). Dept. of Inorganic Chemistry); Ljungstroem, E. Statens Energiverk, Stockholm (Sweden). Dec 1988. 20p. Project STEV-276-363. Order Number DE90728286. Available from NTIS (US Sales Only), PC A03/MF A01.

It has been unclear if CaO or $CaCO_3$ is the reactive species in the desulfurization process in pressurized fluidized-bed combustion (PFBC), where the high partial pressure of CO_2 should, in terms of elementary thermodynamics, inhibit the calcination of $CaCO_3$. In this investigation the simultaneous sulfation and recarbonation of calcined limestone and calcined $CaCO_3$ (pro analysi) was studied by means of thermogravimetric analysis at atmospheric pressure and 860 deg C. When the samples were exposed to 0.3% SO_2, 70% CO_2, 3% O_2, with balance N_2, the recarbonation reaction initially dominates heavily over the sulfation until it becomes diffusion controlled. The $CaCO_3$ formed subsequently reacts with SO_x (i.e. SO_2 and/or SO_3) producing $CaSO_4$. The sulfation rate of uncalcined $CaCO_3$ (pro analysi) was shown to be comparable with the sulfation rate of calcined material. Thus, it is concluded that the desulfurization in PFBC's is mainly caused by a direct reaction between $CaCO_3$ and SO_x, regardless of precalcination. 7 ill., 1 table and 13 refs.

8411 (STEV-FBT–89-38) **Emissions of nitrous oxide (N_2O) from fluidized bed boilers.** Aamand, L.E. (Chalmers Univ. of Tech., Goeteborg (Sweden). Dept. of Energy Conversion); Andersson, S. Statens Energiverk, Stockholm (Sweden). 1989. 9p. Project STEV-276-201. (CONF-890402–9: 10. international conference on fluidized-bed combustion, San Francisco, CA (USA), 30 Apr - 3 may 1989). Order Number DE90728291. Available from NTIS (US Sales Only), PC A02/MF A01.

Measurements of emissions of nitrous oxide (N_2O) have been carried out on two kinds of fluidized bed boilers. One of them, a circulating fluidized bed boiler has been run with three kinds of fuels at different operating condition. The results of the measurements show that the emission of N_2O depends on bed temperature and fuel. The temperature dependence is explained by the strong influence of temperature on the rate of destruction of nitrous oxide by radicals in the gas phase.

8412 (STEV-TORV–89-8) **The gases which influence the climate.** Svensson, B. (Sveriges lantbruksuniv., Uppsala (SE). Inst. f. mikrobiologi). Statens Energiverk, Stockholm (Sweden). 1989. 12p. (In Swedish). Project STEV-216-091. Order Number DE90728293. Available from NTIS (US Sales Only), PC A03/MF A01.

Combustion of peat produces carbon dioxide which is absorbed by natural boglands. Decomposition of dead plants will emit CO_2 and methane. The greenhouse effect of the latter gas is 20 to 30 times stronger than the effect of carbon dioxide. Thus the boglands contribute to the greenhouse effect. Peat harvesting will restrict the formation of methane. When comparing combustion of peat and coal per produced unit of energy, peat is to be preferred as regards the greenhouse effect. (G.B.) 30 refs.

8413 (Stralenbescherming–40) **Estimation of the radiological consequences of dumping into the atmosphere and upon the surface waters caused by non-nuclear industrial processes in the Netherlands.** Punte, A.; de Meijer, R.J.; Put, L.W. KVI-Groningen Univ.-Min. VROM. Dir. Stralenbescherming Collaboration. Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, The Hague (Netherlands). Directie Stralenbescherming. 25 Jul 1988. 166p. (In Dutch). Order Number DE90705965. Available from NTIS (US Sales Only), PC A08/MF A01 - OSTI.

The objective of this report is to make an estimation of the radiologic burden of the Dutch people caused by losses into the atmosphere and upon the surface waters by the non-nuclear industry in the Netherlands. All minerals and raw materials contain small quantities of radioactive materials. However, the concentrations in most minerals are small, the total amount of radioactivity can be considerable by using large amounts of minerals. As result from losses, storage and/or reuse of the rest of the materials liberated in these processes, a large part of the people may be exposed to an extra amount of ionizing radiation. In this report the risks and risk classes are formulated upon which the industrial branches may be subdivided. Therefore an estimation is made of the radionuclide-transport of the raw materials in various industrial branches. Next is indicated how the amount of the losses from the radionuclide-transport can be translated into limits in the radionuclide-transport. Finally the risks for members of the critical groups and the general individual risks as result from the estimated losses and from this resulting doses for distinguished industry branches. 155 refs., 6 figs., 32 tabs.

8414 (VTT-TIED–999) **Dangerous emission of chemical storage fires.** Kallonen, R. (Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). Palotekniikan Lab.); Murronmaa, I. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). May 1989. 147p. (In Finnish). Order Number DE90728213. Available from NTIS (US Sales Only), PC A07/MF A01.

This literature survey includes catalogs of dangerous chemicals and dangerous combustion products. All together this survey descripes 49 hazards: 10 storage fires of agricultural chemicals, 15 hydrocarbon fires and 23 other chemical storage fires.

8415 **Energy and radiative precursor emissions.** Edmonds, J. (Pacific Northwest Lab., Washington, DC (US)); Scott, M. vp of The 8th Miami international conference on alternative energy sources. Volume 1-2 (Condensed Papers). Vezioglu, T.N. Clean Energy Research Inst. University of Miami, Coral Gables, FL (1988). (CONF-871204–: 8. Miami international conference on alternative energy sources, Miami Beach, FL (USA), 14-16 Dec 1987).

The presence of gases such as carbon dioxide (CO_2), water vapor (H_2O), ozone (O_3), methane (CH_4), and nitrous oxide (N_2O), absorb infrared radiation escaping into space and thereby raise the

earth's average surface temperature from zero degrees Fahrenheit to approximately 60 degrees F. Such gases are collectively referred to as greenhouse gases. Human activities are systematically altering the composition of the atmosphere. In 1800 the concentration of CO_2 was 280 parts per million volume (ppmv) (within an uncertainty range of 260-285ppmv). In 1984 the average annual concentration measured at the Mauna Loa observatory in Hawaii was 344ppmv. This paper examines the recent literature on emissions of CO_2 and other trace gases (OTG's) to draw conclusions regarding an appropriate structure for future emissions forecast models.

8416 Observational and theoretical studies of the greenhouse climate problem. Taylor, K.E. (Lawrence Livermore National Lab., Livermore, CA (US)). vp of The 8th Miami international conference on alternative energy sources. Volume 1-2 (Condensed Papers). Vezioglu, T.N. Clean Energy Research Inst. University of Miami, Coral Gables, FL (1988). (CONF-871204--: 8. Miami international conference on alternative energy sources, Miami Beach, FL (USA), 14-16 Dec 1987).

In loose analogy to a botanical greenhouse, the popular term atmospheric greenhouse correctly conveys the idea that the Earth's surface would be much colder and unfit for life were it not for the atmosphere. Gases such as water vapor, carbon dioxide, ozone and methane absorb much of the infrared radiation emitted by the Earth and return some of it to the surface, essentially reducing the efficiency of the planet's natural means of cooling itself. Measurements have shown that many of the so-called greenhouse gases are increasing significantly. Measurements made over the last century confirm that the concentrations of greenhouse gases in the atmosphere have been globally increasing. Historical and paleoclimatic evidence is also mounting linking changes in atmospheric concentrations of carbon dioxide to global changes in climate. Sophisticated mathematical models, which are the modern climatologists primary prognostic tool, are providing quantitative estimates of future temperature increases that could result from continued increases in the greenhouse gases. The limitations and uncertainties in these model results, however, remain substantial.

8417 Optical quality of a channel cleared in a water cloud by a high-energy CO_2 laser: Turbulent mixing and recondensation. Chitanvis, S.M. (Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545 (US)). *Journal of Applied Physics (USA),* 66(9): 4041-4048 (1 Nov 1989).

Calculations of typical time scales suggest that *recondensation* (which causes a growth of water droplets within a channel cleared in water clouds by a high-energy CO_2 laser beam) and *turbulent* mixing (which brings in a fresh set of unvaporized particles into the channel from the surrounding cloud) both occur on the time scale of a second. We have therefore constructed a unified model which describes the process of recondensation as well as turbulent mixing. For typical parameters of water clouds, it is argued on the basis of detailed numerical calculation that turbulent mixing clogs up the channel faster than recondensation can.

8418 A field investigation of sulfate fluxes to a deciduous forest. Hicks, B.B. (Atmospheric Turbulence and Diffusion Division, Air Resources Laboratory, National Oceanic and Atmospheric Administration, Oak Ridge, Tennessee (US)); Matt, D.R.; McMillen, R.T.; Womack, J.D.; Wesely, M.L.; Hart, R.L.; Cook, D.R.; Lindberg, S.E *Journal of Geophysical Research (USA),* 94(D10): 13003-13012 (20 Sep 1989).

An intensive investigation of particulate sulfur fluxes to a deciduous forest was conducted at Oak Ridge, Tennessee, during May 1983, as part of a multilaboratory program to study the dry deposition of airborne trace gases and aerosols to vegetated surfaces. At this time, the leaf area was approximately 50% of the maximum and was rapidly increasing. Eddy correlation methods were used to measure fluxes of submicron particulate sulfur (presumably sulfate), of submicron particles in three different size ranges, and of ozone above the forest canopy. The measured deposition velocities (v_d) of particulate sulfur peaked at about 1 cm s^{-1} in daytime, but dropped to near zero at night, with a long-term average of about 0.6 cm s^{-1}. When scaled with friction velocity, these values of v_d are consistent with similar measurements taken previously over different surfaces. Measurements and analyses indicate that the flux divergence of particulate sulfur should have caused an error no greater than ± 0.05 cm s^{-1} in v_d estimates. For very small particles (less than 0.1 μm diameter), measured values of v_d were similar to those for particulate sulfate, but deposition velocities for particles in the accumulation size range decreased as particle size increased, and upward components of fluxes were found in daytime convective conditions. During this study, measurements were also made of sulfur deposition to polycarbonate petrie dishes placed in the forest canopy, and to the bucket of a standard wet-dry collector in a forest clearing. These surrogate surface studies produced much smaller values of v_d for sulfate than those derived from eddy correlation, when no scaling as a function of leaf area relative to ground area was applied. © American Geophysical Union 1989

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Refer also to citation(s) 6766, 6767, 6876, 6877, 6879, 6882, 6887, 6972, 7233, 7682, 7727, 8395, 8398, 8401, 8413, 8443, 8469, 8476

8419 (CPS--40-11/14-1989E, pp. 2B45-2B62) **The National Incinerator Testing and Evaluation Program: Characterization of residues from a refuse derived fuel combustion system and a modular municipal waste incinerator.** Sawell, S.E. (Environment Canada, Burlington, ON (Canada)); Constable, T.W. Environment Canada, Ottawa, ON (Canada). Conservation and Protection; Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab. 1989. (CONF-890422--: International conference on municipal waste combustion, Hollywood, FL (USA), 11-14 Apr 1989; MICROLOG--89-03664). In *Proceedings [of the] international conference on municipal waste combustion. Volumes 1 and 2.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN.

Summaries are presented of 2 studies which evaluated various ash streams from a coarse refuse-derived fuel combustion system with fabric filter air pollution control and a modular (2-stage) incinerator with lime-based air pollution control. Ash samples from various parts of each system were collected during operating periods. Ash samples and leachates were analyzed for total metal concentrations, fixed solids content, and leachability. Differences between characteristics of ashes from the 2 facilities are possibly related to differences in combustion processes and incineration technology. The implications for disposal of the ashes are discussed. It is noted that the chemical characteristics of bottom ash and fly ash from a refuse derived fuel system with ferrous recovery were similar, and separate collection to facilitate treatment of fly ash may not be necessary. Conversely, the characteristics of ashes from a modular incinerator were very different, and separate collection of bottom ash and fly ash, and treatment of the fly ash, is warranted. 14 refs., 7 figs., 5 tabs.

8420 (DOE-RW--89.028) **Radioactivity in Northern Ireland soils - December 1986: Final report.** Jenkins, D.W.K. (UKAEA Harwell Lab. (UK). Environmental and Medical Science Div.);. Department of the Environment, London (UK). 1989. 31p. Contract PECD-7/9/326. (AERE-R--12936). Order Number DE90612065. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The main objective of the survey was to establish the radionuclide content of permanent pasture soils. The extent of contamination from the Chernobyl accident was also studied with the use of Cs-134 as an indicator of Chernobyl fallout. A preliminary radiological assessment was performed by referring to the generalised derived limits. Results of the grassland grid survey show that Chernobyl-derived radiocaesium was widely spread throughout Northern Ireland with the exception of the East Coast where the deposition was more localised reflecting the showery-rainfall pattern on the 3rd May 1986. Accumulation of Chernobyl material showed a high correlation with rainfall on that day, which resulted in a substantial increase in Cs-137 levels compared to estimated pre-Chernobyl concentrations in many areas. The main areas affected lay in a band across the country from the North East to the South with a smaller incursion to the North. The plutonium content in soils

from Northern Ireland arising from nuclear weapons fallout was similar to levels found in other surveys completed in Great Britain before Chernobyl. (author).

8421 (ENEA-RT-DISP–89-2) **Chernobyl radiological data for accident consequence assessment: Behaviour in rural areas.** Bottino, A. (ENEA, Rome (Italy). Direzione Sicurezza Nucleare e Protezione Sanitaria); Sacripanti, A. ENEA, Rome (Italy). 1989. 50p. Order Number DE90610844. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

In this draft is presented the results of a first effort to summarize information related to the radionuclides behaviour in rural areas, in order to estimate pathway parameters to assess accident consequences. This topic encloses relevant aspects concerning contamination of rural environment, the most important being: (1) dry deposition velocities; (2) washout coefficient; (3) accumulation in lakes; (4) migration in soil; (5) winter conditions; (6) filtering effects of forests. 31 refs.

8422 (ENEA-RT-PAS–89-7) **^{137}Cs behaviour in fruit trees: Results of a search done using the radioactivity measurements carried out in the period 1987-1988 following the Chernobyl accident.** Monte, L. (ENEA, Casaccia (Italy). Centro Ricerche Energia); Quaggia, S.; Pompei, F.; Fratarcangeli, S. ENEA, Rome (Italy). 1989. 29p. (In Italian). Order Number DE90610845. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The results of measurements carried out during the period 1987-1988, to evaluate the levels of ^{137}Cs and ^{134}Cs contamination in fruit samples and in various components of fruit-trees have been reported. It has been demonstrated that, in the case of an accidental contamination of the air, the contamination of fruit is mainly due to the foliar translocation of radionuclide. Data of radioactivity content in fruits collected through a period of three years show that the radioactivity content in fruit diminishes exponentially. Rough estimates of "translocation coefficient" defined as the ratio (radionuclide concentration in fruit)/(radionuclide deposition on soil), and of the "biological half time" have been carried out in the case of hazel-nut, walnut, apple, chestnut and olive.

8423 (IT–CE-02787, pp. 8) **Practical limits to pump and treat technology for aquifer remediation.** Hall, C.W. (U.S. Environmental Protection Agency, Ada, OK (USA)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

Ground water contamination problems vary greatly in all regards, including their size and depth, the nature of the site geology, and the characteristics of the contaminants, as well as their source. A thorough understanding of all of these factors is critical in developing cost-effective remediation technology and defining the proper role of pumping and treating within a remedial action plan. This paper describes the effects of tailing, sorption, and residual immiscible fluids on the time required for pump and treat remediation of ground water contamination. Major items discussed are the tailing and sorption effects on contaminant removal time and the effects of partition of the contaminants to non-aqueous liquid phase present in the soil. 2 refs., 1 fig.

8424 (IT–CE-02787, pp. 7) **Recovery of heavy organics: Case history.** Campbell, P.L. (International Technology Corp.). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

The background and objectives, design, equipment selection, and program evaluation of two recovery programs using jet pump recovery and progressive cavity pump recovery are described. The recovery program in each case effectively withdraws organics from depths of approximately 100 ft. The successful recovery operations from two sites are presented. The recovery of non-aqueous phase liquids (NAPLs), which are heavier than water from depths up to 150 ft below grade, is described. Two approaches to the equipment and recovery well configurations that can be used to successfully recover NAPLs are discussed in general terms, with illustration of typical installations. 1 tab.

8425 (IT–CE-02787, pp. 19) **Electro acoustical soil decontamination for enhanced hydrocarbon recovery from soil.** Hinchee, R.E. (Battelle Memorial Inst., Columbus, OH (USA)); Muraldihara, H.S.; Stulen, F.B.; Jirjis, B.F.; Wickramanayake, B.B. Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

Non-aqueous phase liquids (NAPL) contamination in the form of coal tars and petroleum sludges from more than 189,000 underground storage tanks in the United States alone pose a significant problem. Following a NAPL spill or release, the liquid typically migrates to the water table, where it spreads out and floats, being lighter than water. In a typical clean-up, the first phase is to recover the free phase floating NAPL. This paper describes a novel separation process called electro-acoustic soil decontamination (ESD) for in-situ removal of organics and heavy metals from contaminated soils. The technical feasibility of the ESD concept is discussed. The program was carried out in two phases: laboratory investigation and field demonstration. The paramatric investigation and bench-scale simulation of the project are outlined. An ESD prototype design is given. 23 refs., 3 figs., 2 tabs.

8426 (IT–CE-02787, pp. 20) **Overview of soil and groundwater monitoring techniques.** Ceroici, W.J. (Alberta Environment, Edmonton, AB (Canada)). Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

Due to high drilling costs and a need for better quality samples, groundwater monitoring techniques have evolved significantly from the monitor well, which is the basic sampling device of the groundwater industry. Numerous designs such as multiple piezometer installations and packer systems have been developed to provide more information about vertical contaminant concentration variations. Vadose zone monitoring techniques are increasingly being employed in an effort to optimize monitor well siting. Of the vadose zone monitoring methods the soil gas survey is proving to be the most useful. Information about the extent of a groundwater contaminant plume can be derived by monitoring the distribution of volatile organic compounds in the vadose zone. Vadose zone monitoring can also provide an early warning of potential groundwater contamination, thereby reducing remediation costs. The application of surface geophysical techniques to environmental problems involving contaminant migration is widespread and gaining in importance. These techniques are a valuable prerequisite to installing a monitoring system by providing qualitative geologic and hydrogeologic information. This information can significantly reduce the number of monitor wells required and improve confidence in monitoring data. 9 refs., 7 figs., 1 tab.

8427 (LA–11541-MS) **Surfactant flooding technology for in situ cleanup of contaminated soils and aquifers—A feasibility study.** Porzucek, C. Los Alamos National Lab., NM (USA). Nov 1989. 31p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-36. Order Number DE90003989. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The process of in situ, surfactant-enhanced soil washing has been investigated to determine its usefulness and limitations. Previous work on this subject has been reviewed critically. Entrapment/displacement mechanisms of nonaqueous phase liquids (NAPLs) in

porous media have been identified and are discussed. The effect of surfactant on each of these mechanisms has been investigated. A joint research project has been initiated with Howard University personnel to determine the effect of surfactant on contaminants that have sorbed onto soil surfaces. Results of this research are necessary to more fully determine the limitations of in situ, surfactant-enhanced soil washing. However, based on field observations of NAPLs and modification of an existing mass-transfer-based model, it is apparent that in situ, surfactant-enhanced soil washing alone will not be a sufficient remedial action plan because it cannot displace enough contaminant to clean the soil to within the Environmental Protection Agency's (EPA's) guidelines of cleanliness. The process shows the most promise when it is used in conjunction with another remedial action plan such as biorestoration. 47 refs., 3 figs., 1 tab.

8428 (NEI-SE–39) **Estimate of environmental impact by deposition and utilization of wase products.** Statens Geotekniska Inst., Linkoeping (Sweden). 1988. 72p. (In Swedish). (CONF-8805342–: Nordiska Geoteknikermoetet, Oslo (Norway), 13-15 May 1988). Order Number DE90705986. Available from NTIS (US Sales Only), PC A03.

Selected papers hae been processed separately for inclusion in the Energy Data Base.

8429 (NEI-SE–39, pp. 43-47) **Estimate of environmental impact by deposition and utilization of waste products.** Kullberg, S. Statens Geotekniska Inst., Linkoeping (Sweden). 1988. (In Swedish). (CONF-8805342–: Nordiska Geoteknikermoetet, Oslo (Norway), 13-15 May 1988). In *Nordiska Geoteknikermoetet*. Order Number DE90705986. Available from NTIS (US Sales Only), PC A05/MF A01; NTIS (US Sales Only), PC A04.

By utilizing waste products, e.g. slag as filling in roads, demands are not raised only for the geotechnical properties. Environmental considerations, i.e. the chemical properties of the product, can determine if utilization should be implemented or the product be deposited. Therefore an estimate of the environmental impact should be made that foretells the course of leaching, considering time and space and also the levels of different pollutants. The scenarios studied are based upon the chemical and geotechnical properties such as hydraulic conductivity, compaction properties and leaching properties as well as water balance and location of deposit or utilization. The article presents how leachwater data and geotechnical data of the waste product are used for prognosis of the course of leaching of a substance of interest. The estimate is conservative in so far as no sorption in the soil is accounted for in calculating the dilution. This type of estimate of environmental impacts should be used to demonstrate the order of magnitude of impacts from deposition or utilization. The leached quantity and content can also be compared with atmospheric deposition by dry deposition and precipitation.

8430 (OH/RD–88-296-K) **The use of cover crops to control tree invasion on a right-of-way near Tobermory. 1. Preclearing conditions and a research proposal.** Brown, D. Ontario Hydro Research Div., Toronto, ON (Canada). 7 Feb 1989. 26p. (MICROLOG–89-04568). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

Investigations were carried out on distribution rights-of-way on the Bruce Peninsula near Tobermory to determine a location suitable for an experimental comparison of the ability of grasses, legumes, and the natural right-of-way vegetation cover to interfere with tree invasion. A location was selected for the experiment. This report describes the preclearing vegetation and soil conditions at that site. A research proposal is also included that outlines the experimental design and discusses additional factors that are desirable in such a study. 38 refs., 3 figs., 6 tabs.

8431 (OH/RD–89-30-K) **The McCowan Road right-of-way study: Stump sprouting and suckering, and the development of woody vegetation in the fourth season following clearcutting.** Brown, D. Ontario Hydro Research Div., Toronto, ON (Canada). 15 Feb 1989. 20p. (MICROLOG–89-04569). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

The study described in this report was initiated in 1984 in order to describe the growth of tree species following clearing of a wooded area for a transmission right-of-way. This report discusses the changes in woody species composition during the first four years of the study, concentrating on the relative importance of root suckers, stump sprouts, and tree seedlings to the formation of the tree canopy. The survival and growth rates of sprouts and suckers associated with selected stumps of the major incompatible species are also reported.

8432 (ORNL–6526/R9) **Environmental regulatory update table, October 1989.** Houlberg, L.M. (Tennessee Univ., Knoxville, TN (USA)); Langston, M.E.; Nikbakht, A.; Salk, M.S. Oak Ridge National Lab., TN (USA). Nov 1989. 104p. Sponsored by U.S. DOE Environment Health & Safety. DOE Contract AC05-84OR21400. Order Number DE90004402. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The Environmental Regulatory Update Table provides information on regulatory initiatives of interest to DOE operations and contractor staff with environmental management responsibilities. The table is updated each month with information from the Federal Register and other sources including direct contact with regulatory agencies. Each table entry provides a chronological record of the rulemaking process for that initiative with an abstract and a protection of further action.

8433 (ORNL/RASA–87/29) **Results of the radiological survey at 28 Long Valley Road, Lodi, New Jersey (LJ047).** Cottrell, W.D.; Floyd, L.M.; Francis, M.W.; Mynatt, J.O. Oak Ridge National Lab., TN (USA). Oct 1989. 15p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. Order Number DE90004250. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Maywood Chemical Works (MCW) of Maywood, New Jersey, generated process wastes and residues associated with the production and refining of thorium and thorium compounds from monazite ores from 1916 to 1956. MCW supplied rare earth metals and thorium compounds to the Atomic Energy Commission and various other government agencies from the late 1940s to the mid-1950s. Area residents used the sandlike waste from this thorium extraction process mixed with tea and cocoa leaves as mulch in their yards. Some of these contaminated wastes were also eroded from the site into Lodi Brook. At the request of the US Department of Energy (DOE), a group from Oak Ridge National Laboratory conducts investigative radiological surveys of properties in the vicinity of MCW to determine whether a property is contaminated with radioactive residues, principally ^{232}Th, derived from the MCW site. The survey typically includes direct measurement of gamma radiation levels and soil sampling for radionuclide analyses. The survey of this site, 28 Long Valley Road, Lodi, New Jersey (LJ047), was conducted during 1985, 1986, 1987. Some radionuclide measurements were greater than typical background levels in the northern New Jersey area. However, results of the Survey demonstrated no radionuclide concentrations in excess of the DOE Formerly Utilized Sites Remedial Action Program criteria. 5 refs., 8 figs., 3 tabs.

8434 (ORNL/RASA–87/30) **Results of the radiological survey at 7 Redstone Lane, Lodi, New Jersey (LJ044).** Cottrell, W.D.; Floyd, L.M.; Francis, M.W.; Mynatt, J.O. Oak Ridge National Lab., TN (USA). Oct 1989. 11p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. Order Number DE90004249. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Maywood Chemical Works (MCW) of Maywood, New Jersey, generated process wastes and residues associated with the production and refining of thorium and thorium compounds from monazite ores from 1916 to 1956. MCW supplied rare earth metals and thorium compounds to the Atomic Energy Commission and various other government agencies from the late 1940s to the mid-1950s. Area residents used the sandlike waste from this thorium extraction process mixed with tea and cocoa leaves as mulch in their yards. Some of these contaminated wastes were also eroded from the site into Lodi Brook. At the request of the US Department of Energy

(DOE), a group from Oak Ridge National Laboratory conducts investigative radiological surveys of properties in the vicinity of MCW to determine whether a property is contaminated with radioactive residues, principally ^{232}Th, derived from the MCW site. The survey typically includes direct measurement of gamma radiation levels and soil sampling for radionuclides analyses. The survey of this site, 7 Redstone Lane, Lodi, New Jersey (LJ044), was conducted during 1985 and 1986. Some radionuclide measurements were greater than typical background levels in the northern New Jersey area. However, results of the survey demonstrated no radionuclide concentrations in excess of the DOE Formerly Utilized Sites Remedial Action Program criteria. 5 refs., 4 figs., 3 tabs.

8435 (ORNL/RASA–87/31) **Results of the radiological survey at 19 Redstone Lane, Lodi, New Jersey (LJ056).** Cottrell, W.D.; Floyd, L.M.; Francis, M.W.; Mynatt, J.O. Oak Ridge National Lab., TN (USA). Oct 1989. 17p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. Order Number DE90003986. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Maywood Chemical Works (MCW) of Maywood, New Jersey, generated process wastes and residues associated with the production and refining of thorium and thorium compounds from monazite ores from 1916 to 1956. MCW supplied rare earth metals and thorium compounds to the Atomic Energy Commission and various other government agencies from the late 1940s to the mid-1950s. Area residents used the sandlike waste from this thorium extraction process mixed with tea and cocoa leaves as mulch in their yards. Some of these contaminated wastes were also eroded from the site into Lodi Brook. At the request of the US Department of Energy (DOE), a group from Oak Ridge National Laboratory conducts investigative radiological surveys of properties in the vicinity of MCW to determine whether a property is contaminated with radioactive residues, principally ^{232}Th, derived from the MCW site. The survey typically includes direct measurement of gamma radiation levels and soil sampling for radionuclide analyses. The survey of this site, 19 Redstone Lane, Lodi, New Jersey (LJ056), was conducted during 1985 and 1986. Results of the survey demonstrated no radionuclide concentrations in excess of the DOE Formerly Utilized Sites Remedial Action Program criteria. The radionuclide distributions were not significantly different from normal background levels in the northern New Jersey area. 4 refs., 4 figs., 3 tabs.

8436 (ORNL/RASA–87/34) **Results of the radiological survey at 32 Long Valley Road, Lodi, New Jersey (LJ046).** Cottrell, W.D.; Floyd, L.M.; Francis, M.W.; Mynatt, J.O. Oak Ridge National Lab., TN (USA). Oct 1989. 19p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. Order Number DE90004251. Available from NTIS, PC A08/MF A01; OSTI; INIS; GPO Dep.

Maywood Chemical Works (MCW) of Maywood, New Jersey, generated process wastes and residues associated with the production and refining of thorium and thorium compounds from monazite ores from 1916 to 1956. MCW supplied rare earth metals and thorium compounds to the Atomic Energy Commission and various other government agencies from the late 1940s to the mid-1950s. Area residents used the sandlike waste from this thorium extraction process mixed with tea and cocoa leaves as mulch in their yards. Some of these contaminated wastes were also eroded from the site into Lodi Brook. At the request of the US Department of Energy (DOE), a group from Oak Ridge National Laboratory conducts investigative radiological surveys of properties in the vicinity of MCW to determine whether a property is contaminated with radioactive residues, principally ^{232}Th, derived from the MCW site. The survey typically includes direct measurement of gamma radiation levels and soil sampling for radionuclide analyses. The survey of this site, 32 Long Valley Road, Lodi, New Jersey (LJ046), was conducted during 1985, 1986, and 1987. Some radionuclide measurements were greater than typical background levels in the northern New Jersey area. However, results of the survey demonstrated no radionuclide concentrations in excess of the DOE Formerly Utilized Sites Remedial Action Program criteria. 5 refs., 6 figs., 3 tabs.

8437 (ORNL/RASA–89/6) **Results of the independent verification of radiological remedial action at 87 East 5th South Street, Monticello, Utah (MS00074).** Crutcher, J.W.; Smuin, M.W. Oak Ridge National Lab., TN (USA). Oct 1989. 7p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. Order Number DE90003981. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

In 1980 the site of a vanadium and uranium mill at Monticello, Utah, was accepted into the US Department of Energy's (DOE's) Surplus Facilities Management Program, with the objectives of restoring the government-owned mill site to safe levels of radioactivity, disposing of or containing the tailings in an environmentally safe manner, and performing remedial actions on off-site (vicinity) properties that had been contaminated by radioactive material resulting from mill operations. During 1984, UNC Geotech, the remedial action contractor designated by DOE, performed remedial action on the vicinity property at 87 East 5th South Street, Monticello, Utah. The Pollutant Assessments Group (PAG) of Oak Ridge National Laboratory was assigned the responsibility of verifying the data supporting the adequacy of remedial action and confirming the site's compliance with DOE guidelines. The PAG found that the site successfully meets the DOE remedial action objectives. Procedures used by PAG are described.

8438 (ORNL/RASA–89/11) **Results of the independent verification of radiological remedial action at 396 South 2nd East Street, Monticello, Utah (MS00085).** Crutcher, J.W.; Smuin, M.W. Oak Ridge National Lab., TN (USA). Dec 1989. 9p. Sponsored by U.S. DOE Nuclear Energy. DOE Contract AC05-84OR21400. Order Number DE90004023. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

In 1980 the site of a vanadium and uranium mill at Monticello, Utah, was accepted into the US Department of Energy's (DOE's) Surplus Facilities Management Program, with the objectives of restoring the government-owned mill site to safe levels of radioactivity disposing of or containing the tailings in an environmentally safe manner, and performing remedial actions on off-site (vicinity) properties that had been contaminated by radioactive material resulting from mill operations. During 1985, UNC Geotech, the remedial action contractor designated by DOE, performed remedial action on the vicinity property at 396 South 2nd East Street, Monticello, Utah. The Pollutant Assessments Group (PAG) of Oak Ridge National Laboratory was assigned the responsibility of verifying the data supporting the adequacy of remedial action and confirming the site's compliance with DOE guidelines. The PAG found that the site successfully meets the DOE remedial action objectives. Procedures used by PAG are described. 34 refs., 2 tabs.

8439 (ORNL/TM–11084) **The use of methanotrophic bacteria for the treatment of groundwater contaminated with trichloroethene at the US Department of Energy Kansas City Plant.** Garland, S.B. II (Oak Ridge National Lab., TN (USA)); Palumbo, A.V.; Strandberg, G.W.; Donaldson, T.L.; Farr, L.L.; Eng, W.; Little, C.D. Oak Ridge National Lab., TN (USA). Nov 1989. 67p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC05-84OR21400. Order Number DE90004349. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

Environmental Sciences Division Publication No. 3256.

This study was conducted to demonstrate the technical feasibility of a trickle-filter methanotrophic bioreactor for the remediation of trichloroethene (TCE) contamination in groundwater. A bench-scale continuous-flow bioreactor was constructed and operated for several months to treat synthetic contaminated groundwater and to identify the rate of TCE degradation and the parameters that control bioreactor performance. With influent concentrations of TCE and trans-1,2-dichloroethene (DCE) of 1 mg/L each and a residence time of 50 min, approximately 50% of the TCE and 90% of the DCE were degraded in a single pass through the bioreactor. Further degradation of TCE was obtained with liquid recycle. The performance of the bench-scale bioreactor indicates that bioremediation of TCE-contaminated groundwater is technically feasible. A 3-month pilot plant project to further develop the process is estimated to cost approximately $180,000. A full-scale plant ranging in size from 50 to 700 gal/min is estimated to cost from $180,000 to $1 million to construct and from $4 to $1 per 1000 gal to operate.

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Refer also to citation(s) 6882, 6888, 7376, 8398, 8401, 8413, 8427, 8428, 8431

8440 (INIS-mf–12025) **The effects on the North Sea and the Baltic Sea of the nuclear accident at Chernobyl.** Meereskundliche Beobachtungen und Ergebnisse. Deutsches Hydrographisches Inst. (DHI), Hamburg (Germany, F.R.). 1987. 72p. (In German). Order Number DE90732340. Available from NTIS (US Sales Only), PC A04/MF A01.

The Institute had been conducting intensive investigations of the radioactive contamination of the North and Baltic Seas ever since the accident occurred. The recorded radioactive fallout was determined from the increase of the measured values in the radiological monitoring network and with the help of the analysis of the water samples taken. The periodic and stereoscopic investigations proved that the deposition varied in terms of intensity and spatial distribution mixing processes led to a rapid decrease in the concentration of activity as early as a few hours after deposition. After a few days, direct gamma spectroscopic determination of individual nuclides without chemical enrichment was no longer possible. This is why the contamination was later determined essentially from the radioactive tracers Cs-134 and Cs-137. A whole lot of samplings were restricted for the gamma spectroscopy by means of evaporation. Owing to its characteristic nuclide mixture, the fallout should be clearly distinguished from the contaminations resulting from the reprocessing plants of Sellafield and La Hague. The decrease in concentration observed, which results from mixing processes, also applies to other contaminants from the atmosphere. Despite the long courses of analysis, a series of Sr-90, Pu-239, Pu-238, Am-241 and Cm-242 determinations were carried out. T determinations were interrupted for the time being because the analysis of a rainwater sample with high radioactive contamination did not show any significant increase in the T concentration. On the whole, the data obtained do not reveal any direct external radioactive threat to the biosphere, as far as the sea areas are concerned. (orig./HP).

8441 (INIS-mf–12030) **Isotope dispersion in the vicinity of a radioactive source in the deep North Atlantic Sea. Final report.** Bock, M.; Mittelstaedt, E.; Klein, H. Deutsches Hydrographisches Inst. (DHI), Hamburg (Germany, F.R.); Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). 1988. 40p. (In German). Contract BMFT KWA 5310 0. Order Number DE90732306. Available from NTIS (US Sales Only), PC A03/MF A01.

In the case of a sudden emission of a large quantity of radionuclides, e.g. by the bursting of a submerged tank with radioactive content, the surrounding water is immediately contaminated and a nuclide cloud will be formed. The study describes the spreading processes in ocean water above mountaneous deap sea bottom in the North Atlantic. The extensive measurements in the NOAMP area during the years 1983 to 1985 constitute the basis of the studies. A connection between the measured concentration values and the low level radioactive waste dumped in the North Atlantic in the past is not recognizable. (DG).

8442 (INS-R–352) **Measurement of steam velocity using radioactive tracers.** Barry, B.J.; McCabe, W.J.; Fitzgerald, G.J.;. Department of Scientific and Industrial Research, Lower Hutt (New Zealand). Inst. of Nuclear Sciences. Apr 1986. 24p. Order Number DE90612084. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

Measurements of steam velocity are to be carried out on completion of the Ohaki geothermal power station to calibrate a Venturi meter to be used there for assessing generation efficiency. This report describes the development of the measurement method, designed to conform as much as possible to the appropriate British standard, and two tests of it that were carried out under similar conditions at the Wairakei power station. The experience gained will enable the measurements at Ohaki to be carried out in the most efficient manner possible. Although there were only two runs in which the full detection system and the full amount of tracer were used it maybe concluded that the measurements will yield values within +- 1% of the true velocities. 2 refs; 11 figs; 9 tables.

8443 (IT–CE-02787, pp. 37) **Aerobic biodegradation of benzene, toluene, and xylene in a sandy aquifer: Data analysis and computer modelling.** Chiang, C.Y. (Shell Development Co., Houston, TX (USA)); Salanitro, G.P.; Chai, E.Y.; Colthart, J.D.; Klein, C.L. Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

An aquifer beneath a gas plant facility in Michigan was monitored by 42 wells over three years to determine the fate of benzene, toluene, and xylene (BTX) in ground water. Results from ten sampling periods showed a significant reduction in total benzene mass with time. These reductions and leakage rates from sources were determined from material balance and nonlinear least-square analysis. The natural attenuation rate was calculated to be 0.95% per day. Spatial relationship between dissolved oxygen and total benzene, toluene, and xylene were shown to be strongly correlated by statistical analysis and solute transport modelling. Laboratory biodegradation experiments were performed to determine possible threshold limits for aromatic hydrocarbons oxidation under varying levels of dissolved oxygen. The results were found to be consistent with field data on the presence of high or low levels of BTX and dissolved oxygen in several monitoring well water samples. Formulas used in this study are included in an appendix.

8444 (IT–CE-02787, pp. 21) **Surface geophysical techniques for investigation and monitoring of groundwater and soil contamination.** Pesowski, M.S. (Geo-Physi-Con Co. Ltd., Calgary, AB (Canada)); King, A.R. Info-Tech, Calgary, AB (Canada). 1989. (CONF-8905248–: Prevention and treatment of groundwater and soil contamination in petroleum exploration and production, Calgary (Canada), 9-11 May 1989; CE–02787). In *Prevention and treatment of groundwater and soil contamination in petroleum exploration and production.* Available from Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN.

This paper gives an introduction to the use of surface geophysical techniques, which have increased significantly in groundwater contamination and waste disposal investigations. The role of geophysics and the criteria required to successfully apply surface geophysics to a site investigations are outlined. The paper points out than an integrated program of surface geophysical surveys and drilling can provide a cost effective and complete site investigation. The geophysical methods used in the investigation include electromagnetic, radar, complex resistivity, seismic, and magnetic techniques. It is concluded that in some cases, the geophysical methods can be used to assist in the location and monitoring of groundwater contaminants or buried wastes, while in other cases they are used indirectly to map subsurface geological features that may control the location of buried waste or the migration of contaminants. Special emphasis is placed on how these techniques are used in western Canada. 9 refs., 9 figs., 2 tabs.

8445 (Juel–2265) **Formation and enrichment of methyl mercury in aquatic systems.** Pereira Torres da Silva, B. Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Inst. fuer Angewandte Physikalische Chemie; Bonn Univ. (Germany, F.R.). Feb 1989. 101p. (In German). Order Number DE90732330. Available from NTIS (US Sales Only), PC A06/MF A01.

For the investigation of the methylation as well as of the absorption and elimination of methyl and ionic mercuries, both the methyl and inorganic mercuries were applied to aquatic model ecosystems, and the increase of the methyl and ionic mercury contents as well as that of the methyl mercury formed from inorganic mercury were observed and compared with unloaded systems. For purposes of control, the methyl mercury was analysed with two independent methods: Gas-chromatographic determination of methyl mercury after the extractive separation of MeHg compounds, and ion exchange vapour AAS; a fair measure of agreement was attained. The rate of methylation as well as that of the absorption and elimination

of methyl and ionic mercuries in different components of the aquatic systems and in some fish organs were examined. (orig./RB).

8446 (KVM–19, pp. 19-35) **DDT, PCB, dioxin,,,. A survey in an environmental chemistry perspective.** Bergman, Aa. (Stockholm Univ. (SE). Wallenberglab.). KVM, the Joint Committee of Power and Heating Producers on Environmental Issues, Stockholm (Sweden). Jan 1989. (In Swedish). (CONF-8805344–: Chlorinated hydrocarbons conference, Stockholm (Sweden), 19 May 1988). In *Chlorinated hydrocarbons.* Order Number DE90728270. Available from NTIS (US Sales Only), PC A03/MF A01.

The lecture treats the problem of halogenated aromatic hydrocarbons from chemical, physical, biological, environmental, climatical, and toxical viewpoints. It is essential that the understanding increases of the enormous complexity of pollutants/poisons that overload the environment. More or less complex mixtures of substrates in products become still more complex through chemical reactions, metabolic transformation and through thermal reactions. Only a few examples of all persistent xenobiotics found in the environment are presented in the lecture. (With 10 figures, 4 tables).

8447 (NEI-NO–83, pp. 199-207) **Integrated snowmelt studies in the Turkey Lakes Watershed.** Jeffries, D.S.; Semkin, R.G.; English, M.C. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

Intensive field oriented studies of the processes controlling the hydrological and chemical fluxes associated with spring snowmelt have been conducted in the Turkey Lakes Watershed (TLW). Annual precipitation is approximately 1200 mm; 30% of this is snow giving normal accumulations to a depth of 100 - 150 cm. Comprehensive measurement of the mass balance of a small (1 m^2) snow lysimeter has shown that the meltwater quality leaving the base of the snowpack is strongly influenced by the occurrence of rain. Spring melt periods, water and chemical input from rain passes directly through the snowpack with little interaction. Spring melt periods with little rainfall occur infrequently at this location; however when they do, differential elution of ions from the pack is observed, ie. 50-60% of H^+, SO_4, and NO_3 are removed with the first 20% of the water. The stream concentration of ions varies greatly throughout the spring melt period with the noteable exception of SO_4. Minimum pH correlates with maximum flow rather than periods of differential elution. A large (>1000 m^2) snow lysimeter located on a 28 degree hillslope was used to evaluate the occurrence of horizontal movement of meltwater along ice-layers within the snowpack. Such lateral movement was significant giving an accentuated spring melt loading of water and ions to the lower portions of the slope. The composition of soil percolate water at different locations up the slope reflect this variable loading. The hydrological mechanism by which the hillslope drained into the lake below was investigated by monitoring the ^{222}Rn concentration in groundwater taken from multilevel piezometers at the base of the slope. Most of the meltwater entering the lake flows along a pathway within the top meter of the soil/till matrix. The occurrence of 'piston flow' was minor. 5 figures, 1 table, 12 refs. (author).

8448 (NEI-NO–83, pp. 259-267) **Modelling pH, alkalinity and runoff in a lakeless forested basin in southern Finland.** Lepistoe, A.; Jaervi, T.; Seuna, P. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

The Swedish PULSE model, with the HBV model as the hydrological part, has been used for simulation of the pH and alkalinity of runoff. In Sweden the model has been applied with good results to forested basins that have lakes. In the present study the model was applied to a forested basin without lakes, in order to test its suitability in this case. The model was calibrated to a small (0.69 km^2) basin using a 12-year time period (1972-83;R^2=0.80 for runoff). Verification was carried out with data of the intensively monitored years 1984-85 (R^2=0.84 for runoff, R^2=0.71 for pH). The results show that the PULSE model can also be applied satisfactorily to basins without lakes. The simulation provides reference values fo use in destinguishing long term changes in the runoff water quality from natural short-term variations. 5 figures, 10 references. (author).

8449 (NEI-NO–83, pp. 269-277) **Effects of forest drainage on the acidity of groundwater and surface water.** Lundin, L. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

Forest drainage is performed in wet soil types. The drainage causes an adjustment of the water conditions through a lowered groundwater level. This achieves a deeper percolation than before water adjustment. The outflow of deeper groundwater increases. It is well known that the chemical composition of the groundwater changes with the soil depth. Often a more acid groundwater exits in the shallow layers with a decreasing acidity with increasing soil depth. With a decreased water content in the organic soil layer follows an aeration which increases the decomposition rate of the organic material. When water percolates it will be enriched with inorganic a organic acids. These acids will increase the weathering of the miner soil to which the water percolates. An increased release of cations will occur. In these mineral soil layers the groundwater has a natur higher pH as compared to the organic soil layers. The natural pH of the groundwater outflow from the mineral soil layers will be further improved by the released cations. The improvement will be seen in the surface water as an increased pH, alkalinity and content of cations. 3 figures, 1 table, 7 references. (author).

8450 (NEI-NO–83, pp. 279-288) **Heavy metals in relation to water quality and catchment soil texture in forest lakes.** Mannio, J.; Verta, M. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

Thirty three small, oligotrophic headwater lakes were sampled for heavy metal analysis after the ice had melted in 1985. The concentration levels (in $\mu g/^{-1}$:Cd 0.01-0.56, Cu 0.02-1.7, Pb 0.04-4.7, Zn 0.31-17.5 and Ni 0.01-2.2) were in agreement with previous results for similar small forest lakes in Norwegian and Swedish surveys. The highest values obviously exceed the background level fo areas with no local heavy metal pollution. The concentration of meta (except copper and iron) were significantly higher in headwater lake on the southern coast than in other areas in Finland. The highest heavy metal concentrations were recorded in lakes with catchments of exposed bedrock or thin soil. Only zinc concentrations were significantly negatively ($P<0.01$) correlated with the pH-values. It is likely, that increased leaching from soils due to acidification has raised the levels of Al and Mn in lakes of this type in southern Finland. Higher concentrations of Cd, Pb, Zn and Ni are probably caused by increased atmospheric deposition, and to some extent enhanced by subsequent increased leaching from soils and sediments. Generally, low heavy metal levels were met in esker lakes with sand and gravel soils in the catchment area. 1 figure, 4 tables, 14 reference (author).

8451 (NEI-NO–83, pp. 289-298) **Influence of atmospheric precipitations on the formation of the groundwater chemical composition on the territory of the Byelorussian Polessie.** Pashkevich, V.J. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

Data on the chemical composition of atmospheric precipitations, underground and surface waters on the territory are given. The inflow of salts with atmospheric precipitations influences mostly th chemical composition of groundwaters of the watershed areas and high moors. A part of the atmospheric component in the balance of the maj constituents may reach with this 28-74 per cent. It is shown that th soils, cover and water-bearing rocks on the territory as well as the region underground and surface waters have a very low capability to neutralization of atmospheric precipitations acidity. The results of the regime observations during 1976-1986 indicate that the acidity o atmospheric precipitations does not rise and their quality does not rise and their quality does not become worse. Major anthropogenic factors mostly influencing the chemical composition of underground a surface waters of the region are extensive drainage reclamations, th fertilization of agricultural lands, soil liming, waste and insustri pollution. 1 figure, 4 references. (author).

8452 (NEI-NO–83, pp. 299-311) **Acidification and trace metals in forest lakes near Oslo.** Riise, G.; Hougve, D. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

In a regional survey, carried out during 1983, 56 lakes were investigated with respect to ionic composition, pH, organic content and trace metals. The investigated area is situated just outside Osl city, and is subject to air pollution of both local and remote origi The bedrock consists mostly of gneisses and granites covered with shallow soils. The pH-values in the lakes varies from 4.5 to 7.2 and SO_4 is the dominant anion. Lakes situated above and below the marin level show significant differences with respect to pH, alkalinity an the relative importance of atmospheric influence. The pH-value of th lakes is mainly governed by the buffer system of hydrogencarbonate a organic acids. Many of the lakes were probably supersaturated with respect to pCO_2 atm., which may have contributed to a pH depression Earlier pH measurement gives no evidence for lake acidification of t whole area, but low alkalinity values and high sulphate values may b due to an increased loading of atmospheric acids. The geographical distribution of trace metals in the lakes sems to be determined by t pH-value and organic content. 7 figures, 2 tables, 18 references. (author).

8453 (NEI-NO–83, pp. 209-218) **Preliminary chemical comparisons of Maine, USA, Small Lakes, with the results of the U.S. EPA Eastern Lake survey.** Kahl, J.S. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

Two projects are underway in the State of Maine, USA, to characterize the chemistries of the lakes at elevation greater than 600 meters, and the lakes hydrologically associated with aquifers. These data sets are compared with the statistical population estimates from the USEPA 1984 Eastern Lake Survey (ELS) for Maine. As a population, the high elevation lakes appear to be chemically similar to ELS lakes, but with distributions for pH, ANC, and conductance shifted toward lower values. The aquifer lakes have lower pH, ANC, a conductance than either ELS or the high elevation lakes, but median SO_4 concentration are only 60% of the ELS value. Preliminary indications are that the aquifer lakes are more influenced by organi acids than the other groups, relative to possible impacts from acidi deposition. 5 figures, 1 table, 12 references. (author).

8454 (NEI-NO–83, pp. 229-238) **Contribution of acidic organic anions to the ion balance of lake waters.** Kortelainen, P.; Mannio, J. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

Ion balances were calculated for water samples from 73 forest lakes using the main cations and inorganic anions. A clear excess of cations (σCations/σAnions = 1.6) was observed in polyhum lakes. This indicated the precence of undetected acidic organic anions, which are generated as a result of the incomplete oxidation decomposing organic matter. The organic anion concentrations we calculated , using the empirical model of Oliver et al. (1983). When the estimated organic anions were taken into account, the ion ratios of the coloured water samples were found to balance (σCations/σAnions =1.0). The organic anion concentration also calculated from the measured weak acid concentrations in sample 26 lakes. The estimates of acidic organic anion concentrations determined by the three methods corresponded rather well with each other. Strong mineral acid anions were responsible for the acidity o the clearest lakes. The contribution of organic matter to the acidit of humic waters was confirmed by a significant correlation ($r=0.495$, $P<0.001$) between DOC concentration (5 mg/1 <DOC< 30 mg/1) and pH of the samples. On the basis of the above three methods, one third of t observed acidity in polyhumic lakes was on the average due to organi matter. 2 figures, 2 tables, 16 references. (author).

8455 (NEI-NO–83, pp. 239-248) **Determining acid deposition in snow in northern Finland.** Kubin, E.; Lippo, H. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

The changes of conductivity, pH, SO_4, NO_3, NH_4, PO_4, K, Al, Mg, Ca, and Na during the snowmelt period were studied. The results showed that it is possible to receive the reliable picture of deposition, if the snow in spring is collected before the beginning the snowmelt period. To determine regional differences in deposition snow samples were collected before the snow has started to melt. Research area was the administrative district of Oulu and grouping the sample points was done by cluster analysis. 6 figures, 8 references. (author).

8456 (NEI-NO–83, pp. 249-258) **Acidification of Hardangervidda, Telemark, a high mountain area in southern Norway.** Kulsvehagen, E. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

Poorly buffered freshwaters in the high mountain plateau, was investigated during four periods, autumn 1983 and 1984 and spring 19 and 1985. The investigated area covered more than 5000 km^2, 229 lak and 575 samples. Most of the lakes were small, less than 50 ha locat at altitudes from 535 to 1520 m above sea level. The ionic compositi of high mountain lakes located in geological formation of granite an gneiss, are low, less than 1.5 mS/m. The pH-level in 140 lakes, in April/May 1984 and 1985, varied between 4.1 -6.5. In 25% of the lake the pH increased by 50%, from 1.7 mg So_4/l to 2.6 mg So_4/l as average in snowmelting. 25% of the lakes had bicarbonate concentrati of μeqv/1 and 90% of the lakes investigated in September 1983 and 1984 had bicarbonate (HCO_3) less than 50 μeqv/1. Based on calciu and bicarbonate concentration, the acidification of Hardangervidda w calculated to be in the order of 30-50 μeqv/1. 7 figures, 17 references. (author).

8457 (NEI-NO–83, pp. 313-321) **Fish kills related to water chemistry in a Norwegian salmon river.** Roegeberg, E.J.S. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

A combination of low pH, high labile aluminium and low calcium values is thought to create toxic conditions to aquatic organisms. Continous monitoring of the river Vikedal in South-western Norway wa carried out during the snowmelt periods 1985 and 1986 in order

to evaluate the effects of short term variations in water quality (episodes) on aquatic organisms. Continous monitoring of pH and aluminium was carried out, and daily values of calcium concentration and water level were recorded. The water quality measurements were combined with studies of behaviour and mortality of fish and invertebrates. In 1986 fish kills were recorded both in an experimental fish tank and in the river itself. The majority of the salmon presmolts in the experimental fish tank died after a 12 day period of pH between 5.1 and 5.3, labile aluminium between 50 and 65μ/l and calcium between 0.55 and 0.75 mg/l. 5 figures, 12 references. (author).

8458 (NEI-NO–83, pp. 323-332) **Peculariities of groundwater chemical composition formation in conditions of atmospheric precipitation influence.** Shpakov, O.N.; Pashkovitch, N.N. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

In B/elorussia (USSR) the atmospheric precipitations are acid or near to neutral. Their higher acidity level is registered mainly in winter.In summer their mineralization and alkality is rising. Groundwater chemical composition is predetermined by interaction with rocks. Acid atmospheric precipitations intensify the process of water and rocks interaction which begins in the atmosphere. Atmospheric precipitations dissolve dust particles of the atmosphere that result in the increase of mineralization and alkality of precipitations. In summer the samples of atmospheric precipitations should be taken a few hours later after their fall to avoid the atmospheric dust influence. In winter 3-5 sm of the upper layer of the newly fallen snow is chosen as a sample. The exact regularity of acidity-alkality changes in time is not marked. Chemical composition study of atmospheric precipitations is of great importance for the estimation of chemical substances balance on the Earth surface in connection with the anthropogenic influence on hydrosphere and the level groundwater pollution investigations. Interconnection of acid atmospheric precipitations with different directions of air mass transference is the evidence of broad-scaled acidification and requires deep and detailed study. 2 figures, 2 tables, 5 references. (author).

8459 (NEI-NO–83, pp. 333-342) **Acid meltwater and chemical processes in soil media.** Soveri, J.; Ahlberg, T. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

This study was carried out at four percolationwater stations in Finland. The Stations have 3 collection pipes at different depths of soil profile. The pipes have been installed under the organic topsoi layer, to the enrichment layer, and the layer under the podzol layer Electrical conductivity, pH, alkalinity, the concentration of sulphate, ion, manganese, silicate, sodium, potassium, calcium, magnesium, aluminium, cadium and zinc of the percolating water was analyzed. At two stations, where there is gravel and sand, where the permeability is high, the major changes were noticed at the layer under the podzol layer. At the two other stations of finer soil type the major changes were noticed already at the upper leaching and enrichment layers because of the longer delay of percolation. 5 figures, 1 table, 8 references. (author).

8460 (NEI-NO–83, pp. 343-352) **Heavy metals in sediments; indicators of airborne pollution.** Verta, M.; Mannio, J. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

Sediment cores from 16 small headwater lakes were analysed for Al, Na, K, Ca, Mg, Ti, Fe, Mn, Ni, Cu, Zn, Cd, Pb, and Hg. Seven of the lakes has undergone recent severe or slight acidification, three had remained as acid for hundreds of years, and four were circumneutral. The results showed a general increase in several major cations (Na, Mg, Ti) at the surface of the cores in southern and central Finland, thus indicating changes caused by soil acidification and/or erosion the catchment area. The most prominent increase was observed in the concentration and consequuent sedimentation, beginning as early as t 18'th or 17'th century in southern Finland. A slight increase in Hg the 19'th century was also observed. All these changes were interpreted primarily as a consequence of increased atmospheric deposition of these elements. 3 figures, 1 table, 10 references. (author).

8461 (NEI-NO–83, pp. 355-362) **Acidification of groundwater supplies in Sweden.** Broemssen, U. von. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

The quality of drinking water from groundwater supplies has changed in Sweden and in many countries in Europe since the 1950s. Changes influenced by acidification may be caused by atmospheric depositions, by nitrogen fertilizing in farming and/or changes in la use. This paper presents the effects of drinking water influenced by atmospheric deposition only. A presentation is made of the atmospher acid loading, the base production from wethering of silicate mineral and 24 municipals well surveys. 4 figures, 10 references. (author).

8462 (NEI-NO–83, pp. 360) **Hydrogen ion budgets of four forested small basins in Finland.** Kallio, K.; Kauppi, L. Norsk Hydrologisk Komite, Oslo (Norway). 1987. (CONF-870577–: International symposium on acidification and water pathways, Bolkesjo (Norway), 4-8 May 1987). In *Acidification and water pathways. Vol. 2. Proceedings of International symposium on acidification and water pathways, Bolkesjoe, 4-5 May 1987.* Order Number DE89787775. Available from NTIS (US Sales Only), PC A16/MF A01.

Hydrogen ion budgets were calculated for four forested drainage basins in order to quantify the acidifying and neutralizing processe The dominant forest type of the basins was coniferous. The internal processes of the hydrogen ion budget were quantified indirectly on t basis of differences between ion output and deposition. Biological accumulation was not considered independently because of insufficien data. The deposition was measured in an open field using bulk deposition. The production of hydrogen ions varied between 65 and 16 keq $km^{-2}a^{-1}$ and the consumption between 90 and 210 keq $km^{-2}a^{-}$ 1. The consumption was in most basins larger than the production. Quantitatively the most important process production hydrogen ions w the dissolution ans dissociation of CO_2. Hydrogen ion consumption caused by sulphate retention was considerable in two basins with hig percentages of peatland. The budget discrepancies may be due to dissociation of organic acids and aluminium transformations, which were not included in the calculations. Another source of inaccuracy was the lack of throughfall measurements. 3 figures, 3 tables, 12 references. (author).

8463 (NHL–284053) **Environmental conditions at Tromsoeflaket: Results of measurements from: 1980-1983.** Hansen, S.E.; Loenseth, L.; Solli, P.; Stang, O. Norsk Hydroteknisk Lab., Trondheim (Norway). Apr 1984. 320p. (STF–60A84053). Order Number DE90728248. Available from NTIS (US Sales Only), PC A14/MF A01.

This report contains: Current data from 1980-1983. Wave data from 1981-1983. The measurements are taken from weathership AMI in position:71°30'N, 19°00'E. 305 tables, 100 drawings.

8464 (OH/RD–88-185-K) **Mississagi River bank stabilization program aquatic monitoring, 1987.** Sheehan, R.W. Ontario Hydro Research Div., Toronto, ON (Canada). 2 Sep 1988. 38p. (MICROLOG–89-04437). Available from PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN.

Water quality, fish spawning habitat and fish species distribution below Red Rock (Ontario) Generating Station on the Missisagi

River were monitored in 1987 as the final year of a three year study to determine the effect of bank stabilization on the aquatic environment. Water quality parameters indicated no detrimental effect to the river system. Spawning bed particle size analysis also indicated no significant variation in substrate composition. Yellow perch was the dominant fish species collected in 1987 during day sampling. The 1987 day fish catch was lower than in previous years with only four fish collected at the construction sites. Night fish abundance declined in 1987 with lower numbers of fish collected at the construction sites. The yearly variations in total fish numbers and total fish abundance at sampling locations were not significant. However, the total fish catch was significantly improved at the treated sites when compared to the cobble/boulder and sand control site fish catches. Significant variations were also present among years and substrates in adult and juvenile/young of the year fish abundances. The adult fish catch was greater at the treated sites while juvenile/young of the year numbers were greatest at cobble/boulder control sites. The survey results did not indicate any detrimental changes to the fish population in the study area as a result of the bank stabilization. The variation in fish abundance, distribution and species composition may have been related to low water levels during the 1987 survey, natural fish distribution and population changes and change in electrofishing equipment used. 5 figs., 7 tabs.

8465 (ORNL/TM–10265) **The Oak Ridge Y-12 Plant biological monitoring and abatement program for East Fork Poplar Creek.** Loar, J.M. (Oak Ridge National Lab., TN (USA)); Adams, S.M.; Allison, L.J.; Giddings, J.M.; McCarthy, J.F.; Southworth, G.R.; Smith, J.G.; Stewart, A.J. Oak Ridge National Lab., TN (USA). Oct 1989. 80p. Sponsored by U.S. DOE Environment Health & Safety. DOE Contract AC05-84OR21400. Order Number DE90004397. Available from NTIS, PC A05/MF A01 - OSTI; GPO Dep.

Environmental Sciences Division Publication No. 3348.

In May 1985, a National Pollutant Discharge Elimination System permit was issued for the Oak Ridge Y-12 Plant, a nuclear weapons components production facility located in Oak Ridge, Tennessee, and operated by Martin Marietta Energy Systems, Inc., for the US Department of Energy. As a condition of the permit, a Biological Monitoring and Abatement Program (BMAP) was developed to demonstrate that the effluent limitations established for the Oak Ridge Y-12 Plant protect the classified uses of the receiving stream (East Fork Poplar Creek), in particular, the growth and propagation of fish and aquatic life, as designated by the Tennessee Department of Health and Environment. A second purpose for the BMAP is to document the ecological effects resulting from implementation of a water pollution control program that will include construction of nine new wastewater treatment facilities over the next 4 years. Because of the complex nature of the effluent discharged to East Fork Poplar Creek and the temporal and spatial variability in the composition of the effluent (i.e., temporal variability related to various pollution abatement measures that will be implemented over the next several years and spatial variability caused by pollutant inputs downstream of the Oak Ridge Y-12 Plant), a comprehensive, integrated approach to biological monitoring was developed for the BMAP. 39 refs., 5 figs., 8 tabs.

8466 (ORNL/TM–11061) **A computer program for estimating fish population sizes and annual production rates.** Railsback, S.F.; Holcomb, B.D.; Ryon, M.G. Oak Ridge National Lab., TN (USA). Oct 1989. 62p. Sponsored by U.S. DOE Environment Health & Safety. DOE Contract AC05-84OR21400. Order Number DE90004359. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This report documents a program that estimates fish population sizes and annual production rates in small streams from multiple-pass sampling data. A maximum weighted likelihood method is used to estimate population sizes (Carle and Strub, 1978), and a size-frequency method is used to estimate production (Garman and Waters, 1983). The program performs the following steps: (1) reads in the data and performs error checking; (2) where required, uses length-weight regression to fill in missing weights; (3) assigns length classes to the fish; (4) for each date, species, and length class, estimates the population size and its variance; (5) for each date and species, estimates the total population size and its variance; and (6) for each species, estimates the annual production rate and its variance between sampling dates selected by the user. If data from only date are used, only populations are estimated. 9 refs.

8467 (SI/R–89243-1) **Multivariate correlation patterns of polycyclic aromatic hydrocarbons in sediments.** Vogt, N.B. Senter for Industriforskning, Oslo (Norway). Apr 1989. 29p. Order Number DE90728216. Available from NTIS (US Sales Only), PC A03/MF A01.

Three different methods of multivariate classification and data-analysis are applied to illustrate how pattern recognition may be used to cluster and polish classes of sediment samples in a data set described by 12 alkyl naphthalenes, phenanthrenes and dibenzothiophenes. Subsequent supervised principal component analysis of the polished sample classes in then used to obtain principal component variable discriminant plots. This analysis shows that samples considered not to be influenced by a local source of pollution, exhibit multivariate correlation patterns which are similar to samples wich are clearly influenced by the same source. 30 refs., 4 figs., 5 tabs.

8468 (SI/R–881003) **Concequences of oil pollution for the fish farming industry: Oil pollution from the Haltenbanken transport system.** Hem, K.-G.; Seip, K.L. Senter for Industriforskning, Oslo (Norway). Nov 1988. 60p. (In Norwegian). Order Number DE90728225. Available from NTIS (US Sales Only), PC A04/MF A01.

A description is given of expected damage and "worst case" damage on fish farms as a consequence of oil pollution in connection with transport of oil from Haltenbanken. Statistically, the expected damage on the fish farms from the transport systems (pipelines) for gas and gas/oil from Haltenbanken is one farm damaged per ten years. The northernmost pipe alignment route will entail the greatest expected damage, but there is not so much difference from the other routes that decisive importance should be attached to this element. The expected economic loss per 10 year is between 3.1 and 6.5 million NOK for the various alternatives. This corresponds to a temporary decline in employment of up to four manyears in the region. 25 refs., 14 figs., 21 tabs.

8469 (SNV–3584) **Liming and fertilization in the lakes Lake Ramm and Aemten in Oerebro County 1980-1987.** Andersson, P. (Statens Naturvaardsverk, Solna (SE)); Hoernstroem, E.; Grahn, P.; Nyberg, P.; Dahlquist, K. National Swedish Environmental Protection Board, Solna (Sweden). Apr 1989. 123p. (In Swedish). Order Number DE90728302. Available from NTIS (US Sales Only), PC A06/MF A01.

The mercury content was followed up, every 3 years in full-grown pike and perch, and yearly in young specimens during the years 1980-1986 except for 1981 1nd 1985. Both lakes were limed at 3 occasions and were fertilized yearly during the vegetation period. In Lake Ramm also roach was re-introduced. In addition the Hg contents have been followed in sediments and plankton. The Hg-studies are supported water-chemically and biologically by qualitative and quantitative plankton anaiyses and by test fishing. In the Ramm lake, which at the test start was the less acid of the two lakes, the mean pH value being slightly above 5, lower Hg contents were obtained in all fish except for full-grown pike after 2-3 years. However, after 6 years the contents in full-grown pikes were halved. In Aemten the Hg content rose in all fish on the whole for the first 2 to 3 years. After that it decreased in all fish except for full-grown pikes where the contents remained unchanged. This development of the Hg contents in Aemten is supposed to be caused of mechanisms that have led to fixing or inhibiting take-up in fish with continuously decreasing contents in the course of changes in the acidity of the lake from moderate to high values. When Aemten was limed these processes were forced in an opposite direction during the first years at which the contents increased. Not until these processe had ebbed during the first years other mechanisms have started. Then the Hg contents dropped during the last part of the period. 38 illustr., 16 tabs., 61 refs.

8470 (SNV–3585) **Project Liming-Mercury-Cesium. Activity report 1988.** Haakansson, Lars (Uppsala Univ. (SE). Hydrologiska avd.). National Swedish Environmental Protection Board, Solna (Sweden). Feb 1989. 35p. (In Swedish). Order Number

DE90728303. Available from NTIS (US Sales Only), PC A03/MF A01.

This is the third yearly progress report from the project, which started in January 1986 and will end 1990. Within the framework of the project a sub-project, 'Measures to reduce high concentrations of radioactive cesium in fish', is run. The basic question is: How is it possible to reduce the mercury and cesium contents in fish, and the threat of 'blacklisting' which is presently acute for thousands of Swedish lakes? What measures could be taken? The aim of the project is to make systematic studies and test various possible means and combinations of means, like liming of lakes, of wet land and of entire drainage areas, fertilization with commercial fertilizers and with nutrients from fish cage farms, intensive fishing and adding of potash. The goal is to present practical recommendations to regional and local environmental agencies on suitable methods to reduce the contamination in fish. Comprehensive investigations are presently carried out in 95 lakes in different parts of Sweden. Pike and perch are used as biological test organisms. The load of mercury and radioactive cesium to the lakes is measured in the lake water, in sediment traps and from sediment samples. A broad set of limnological data (pH, transparency, color, Ca, Fe, P, alkalinity, etc.), morphometrical data (volume, depth, bottom types, etc.) and environmental parameters on the drainage area (water discharge, soils, land use, bedrock, etc.) are collected. 10 illustr., 7 tables.

8471 (SNV–3600) **Groundwater acidification in SW Sweden: Analysis of time-series from minor community groundwater supplies.** Jonasson, S.A. (Chalmers Tekniska Hoegskola, Goeteborg (SE). Geologiska Inst.); Laang, L.O.; Swedberg, S. National Swedish Environmental Protection Board, Solna (Sweden). Apr 1989. 58p. (In Swedish). Order Number DE90728304. Available from NTIS (US Sales Only), PC A04/MF A01.

This report deals with long-term changes in pH, alkalinity, total hardness and sulphate content for 12 municipal groundwater wells in SW Sweden. Time series data from between 15 and 24 years for each well are used. An evaluation of the compatibility of each well with time series studies is done, considering the aquifer properties and effects of pumping changes. Most appropriate for the purpose are found to be time series from springs and wells where the pumping is small compared to the aquifer capacity. The wells in Quaternary deposits are divided into three groups: 1. Small aquifers in coarse-grained deposits. Sited in areas with high frequency of bedrock outcrops and peat occurrence. - Unconfined aquifers (2 wells). 2. Large aquifers in vast sand deposits. - Unconfined aquifers (6 wells) 3. Clay areas. - Confined aquifer (1 well). From the time series studies it is evident that: * pH is decreasing, * alkalinity changes are rare, * total hardness is varying, * sulphate content is constant or increasing slightly. The pH-decrease of about 0.3 units is occurring during the first half of the investigated period. Since the late 1970's no changes of pH have been observed. Alkalinity in the unconfined aquifers (groups 1 and 2) is low during the whole period (10-30 mg/l). Since the 1960's no trends towards a change have been monitored. Concerning some of the wells no information about sulphate content is available. Time series from three drilled wells in fractured bedrock have been evaluated. In two of them, both with alkalinity about 50 mg/l, indications of acidification are registered. pH and alkalinity decrease with time while total hardness increases.

8472 (SNV–3606) **Liming in Sweden. Report 1989.** Brodin, Y.W. National Swedish Environmental Protection Board, Solna (Sweden). 1989. 24p. (In Swedish). Order Number DE90728333. Available from NTIS (US Sales Only), PC A03/MF A01.

The report presents an account of liming measures to prevent acidification of lakes and watercourses. A report of this kind is planned to be issued yearly and to present a general description of the conditions. Some numbers are also planned to be devoted to some urgent topic. The liming measures are done, today like earlier, mainly to protect fish species and crawfish of particular value to professional as well as leisure fishing. 8 figs., 3 tabs., 33 refs.

8473 (SNV–3608) **Background conditions and measures accomplished in the lakes of the PU-laboratory: Project Liming-Mercury-Cesium.** Andersson, P. (Statens Naturvaardsverk, Solna (SE). PU-lab); Borg, H.; Olsson, B.; Haakanson, L.; Nilsson, Aa. National Swedish Environmental Protection Board, Solna (Sweden). Mar 1989. 69p. (In Swedish). Order Number DE90728305. Available from NTIS (US Sales Only), PC A04/MF A01.

The aim of this report is to present results concerning limnological data and the mercury situation before the remedial measures have been started and to give a thorough account of the measures used in the 19 lakes handled by the PU-laboratory at the National Swedish Environmental Protection Board. Similar reports are simultaneously being produced for the other so-called type lakes in the project. The lakes discussed in the report are not studied for cesium. The data presented here will be used in the subsequent analysis on the linkage between Hg-load (dose) and Hg in fish (effect) and the environmental factors that may have an impact on the relationship between dose and effect. 12 tabs., 4 figs., 60 refs.

8474 (SNV–3610) **Liming tests near acid drilled wells in bedrock, Gothenburg area, southwestern Sweden.** Jonasson, S.A. (Chalmers tekniska hoegskola, Goeteborg (SE). Geologiska inst.); Laang, L.O.; Swedberg, S. National Swedish Environmental Protection Board, Solna (Sweden). May 1989. 44p. (In Swedish). Order Number DE90728306. Available from NTIS (US Sales Only), PC A03/MF A01.

Acid groundwater in wells drilled in bedrock has been found in areas with high acidification sensitivity. Within certain small areas, e.g. in the Gothenburg district, the groundwater in bedrock has similar acidity as the water in the normally more acid dug wells. pH-values < 6.0 are common and sometimes pH is less than 5.5. An investigation whether neutralizing acid groundwater in bedrock through soil liming is possible has been done. The liming was done in November 1985 close to four drilled wells in the neighbourhood of Gothenburg. Fine-grained limestone (<0.1 mm) mixed with water was used. The quantity of limestone used was estimated with respect to soil characteristics and added with an excess for the superficial bedrock. Measurements of pH, alkalinity, total hardness and conductivity to determine the effects of the liming, have been carried out during a period of two years. The water in the drilled wells and shallow groundwater from observation wells have been regularly analysed. Effects are noticed in the observation wells within and close to the liming areas. Also, the soil chemistry has been measured. Base saturation in the soil has increased from 20% to 60%. However, no effects have been observed in the drilled wells. Results from other liming tests carried out in Sweden indicate that it takes longer time than expected to improve the water with soil liming on the ground surface. 5 figs., 2 tabs., 26 refs.

8475 (SNV–3617) **Injection of limestone slurry as a measure for alkalization.** Sundloef, B. (VBB AB, Stockholm (SE). Vatten Mark Miljoe). National Swedish Environmental Protection Board, Solna (Sweden). Jun 1989. 71p. (In Swedish). Order Number DE90728307. Available from NTIS (US Sales Only), PC A04/MF A01.

A method for in situ alkalization of groundwater in sand and gravel formations has been tested. The method implies infiltration of limestone slurry below the groundwater table by way of perforated pipes. The main object for alkalization of acidified groundwater is to decrease its corrosive properties. The aim is normally to reach a pH-value > 6.5 and an alkalinity > 60 mg/l. An other object is to prevent solution of metals from the soil material, which normally is obtained if the pH-value can be kept > 6.

8476 (VTT-SYMP–102, pp. 345-354) **Industrial application of liquid emulsions technique.** Marr, R. (Institute of Chemical Engineering, Technical University, Graz (Austria)); Lackner, H.; Draxler, J. Valtion Teknillinen Tutkimuskeskus, Espoo (Finland). 1989. (CONF-8806445–: Seminar on non-waste technology, Espoo (Finland), 20-23 Jun 1988). In *Non-waste technology: Volume 1.* Order Number DE90728202. Available from NTIS (US Sales Only), PC A20/MF A01; NTIS (US Sales Only), PC A19/MF A01.

Liquid Membrane Permeation is a new technique for treatment of waste waters, which has been industrialized recently. It is especially suitable for low concentrated aqueous solutions containing heavy metals and other anorganic and organic contaminants, which are quantitatively removed from the waste water and simultaneously concentrated in the stripping phase. A survey is given on the development situation and the industrial applications.

8477 (WSRC-RP–89-1039) **Molecular analysis of deep subsurface bacteria.** Jimenez, L.E. Westinghouse Savannah River Co., Aiken, SC (USA). Nov 1989. 111p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. Order Number DE90003987. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

Thesis submitted by Luis E. Jimenez to the Puerto Rico Resource Center for Science and Engineering.

Deep sediments samples from site C10a, in Appelton, and sites, P24, P28, and P29, at the Savannah River Site (SRS), near Aiken, South Carolina, were studied to determine their microbial community composition, DNA homology and mol %G+C. Additional studies were done in adjacent groundwater wells at the 3 SRS sites. Different geological formations with great variability in hydrogeological parameters were found across the depth profile. Sediment age ranged from 37 to 85 million years old. Bacterial densities by acridine orange direct counts (AODC) and viable counts on 1% PTYG media were significantly higher at deep sediments than in groundwater wells. Metabolic tests of bacterial isolates showed no significant difference between both habitats. However, sediment isolates showed higher percentages in the carbon assimilation tests than groundwater isolates. Phenotypic identification of deep subsurface bacteria underestimated the bacterial diversity at the three SRS sites, since bacteria with the same phenotype have different DNA composition and less than 70% DNA homology. The mol %G+C of deep subsurface bacteria ranged from 20 to 77%, with more than 60% and 12% of the isolates tested showing values similar to the *Pseudomonas* spp. and *Acinetobacter* spp., respectively. 200 refs., 18 figs., 24 tabs.

8478 (WSRC-RP–89-1058) **Fish survey of Pen Branch and Indian Grave Branch.** Mealing, H.G. (Normandeau Associates, Inc., Aiken, SC (USA). Southeastern Regional Office); Heuer, J.H. Westinghouse Savannah River Co., Aiken, SC (USA); Normandeau Associates, Inc., Aiken, SC (USA). Southeastern Regional Office. Feb 1989. 14p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. (NAI-SR–97). Order Number DE90004269. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The objective of this ongoing study is to provide additional information for characterization of the fish communities of Pen Branch and Indian Grave Branch prior to the restart of K-Reactor. 3 refs., 8 tabs.

8479 (WSRC-RP–89-1060) **Fish survey of Pen Branch and Indian Grave Branch.** Mealing, H.G.; Heuer, J.H. ECS/Normandeau, Aiken, SC (USA). Dec 1988. 13p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. (ECS-SR–95). Order Number DE90003885. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The objective of this study was to supplement information collected in November, for characterization of the fish communities of Pen Branch and Indian Grave Branch prior to the restart of K-Reactor. 2 refs., 9 tabs.

8480 (WSRC-RP–89-1063) **Quantitative macroinvertebrate survey of Pen Branch and Indian Grave Branch.** Westinghouse Savannah River Co., Aiken, SC (USA); Enwright Environmental Consulting Labs., Greenville, SC (USA). Mar 1989. 24p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. Order Number DE90003890. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A total of 90 species were collected at all sites on Pen Branch and Indian Grave Branch during the 28 day period for colonization of the multiplate artificial substrate samplers. Upstream site 2 demonstrates the highest species richness (20.4), followed by site 5 (20.0). The average number of species per replicate (15.9) was approximately three species higher than during the previous month's sampling, a trend noted at all sites, including the control sites. It would seem that the increase in species richness may be correlated with seasonal changes, rather than being primarily due to a lack of scouring conditions noted during the previous month. Densities of organisms were also much higher. Increased densities did appear to be correlated with the cessation of scouring phenomena, with the greatest changes observed at sites 3, 4 and 7. Biomass was greatest at downstream sites 4 and 5, and smallest at the Indian Grave Branch site (7). Compared to upstream site 2, as well as Upper Three Runs Creek (a nearby stream of similar size), the species richness and density of organisms at downstream sites continues to be suppressed, with the impact lessening with movement downstream from the K reactor. 10 tabs.

8481 (WSRC-RP–89-1064) **Quantitative macroinvertebrate survey of Pen Branch and Indian Grave Branch.** Enwright Environmental Consulting Labs., Greenville, SC (USA). Jul 1989. 23p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. Order Number DE90003894. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A total of 82 species were collected at all sites on Pen Branch and Indian Grave Branch during the 28 day period for colonization of the multiplate artificial substrate samplers. Upstream site 2 demonstrated the highest species richness (32), followed by site 3 (31). The average number of species per replicate (14.3) was slightly lower than during March 1989 sampling, a trend noted at all sites except site 3. Species richness at site 3 increased during May sampling, most notably with the presence of numerous mayflies, which were not collected previously at this site. Densities of organisms were lower than in March sampling, with the greatest changes observed at sites 3, 4, and 5. Biomass was greatest at downstream sites 2 and 4, and smallest at sites 3 and 6. Compared to upstream site 2, as well as Upper Three Runs Creek (a nearby stream of similar size), the species richness and density of organisms at downstream sites continues to be suppressed. However, the more pronounced impact at the first downstream sites (3) noted previously, was not found during May collection. As during the previous month's sampling, results suggest substantial but incomplete recovery of the macroinvertebrate community. 19 tabs.

8482 (WSRC-RP–1062) **Quantitative macroinvertebrate survey of Pen Branch and Indian Grave Branch.** Enwright Environmental Consulting Labs., Greenville, SC (USA). Feb 1989. 31p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. Order Number DE90003891. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A total of 80 species were collected at all sites on Pen Branch and Indian Grave Branch during the 28 day period for colonization of the multiplate artificial substrate samplers. The two upstream sites demonstrated the highest species richness. During the sampling interval a release of significant proportion entered Indian Grave Branch, affecting all downstream sites. This effect was most severe at sites 3, 4, and 7, apparently resulting in heavy scouring of the multiplate samplers. Nevertheless, much colonization did occur at sites 3 and 4, with hydropsychid caddisflies, blackflies and midges predominant. At sites 5 and 6 a greater degree of recovery was noted, due to the lessened scouring in the broad floodplain. These downstream sites had significant numbers of mayflies along with the numerous midges. Considered overall, colonization during the period since the K Reactor has ceased releasing thermal effluent into Pen Branch and Indian Grave Branch has been substantial, introducing a substantial proportion of the species known from other nearby streams. 29 tabs.

55 BIOMEDICAL SCIENCES, BASIC STUDIES

5501 Behavioral Biology

Refer also to citation(s) 7112

8483 **The transition from aerobic to anaerobic respiration during long-term storage of Bartlett pear.** Boersig, M.R. (Univ. of California, Davis (USA)); Kader, A.A.; Romani, R.J. pp. 269 of Plant senescence: its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The treatment of fruit with oxygen concentrations below 1% for storage, or potential insect control, requires cautious avoidance of anaerobic conditions. In this study, the authors examined respiratory

response to anaerobic conditions through the course of maturation and senescence of Bartlett pears. The initial rates of both aerobic and anaerobic respiration increased during long-term storage of pear fruit. It was notable that the increased respiratory potential was realized in the absence of oxygen. Ethanol concentration consistently increased under anaerobic conditions, while malate and methanol showed no increase. Their data inconclusively suggested that lactate may have been produced under anaerobic conditions. There was no discernible increase in ethanol production concomitant with the age-related increase in CO_2 production. Under atmospheres of nitrogen, anaerobic respiration reached its maximum rate of 5 to 7 h, then began a continuous declines. This decline was correlated with ethanol accumulation. Direct evidence that ethanol was the effector in this negative response was not presented.

5502 Biochemistry

Refer also to citation(s) 7151, 7153, 7154, 7155, 7160, 7161, 7165, 7166, 7167, 7168, 7169, 7170, 7171, 7176, 8532, 8596

8484 (CONF-8909189–3) **Tetrahydropterin as a possible natural cofactor in the drosophila phenylalanine hydroxylation system.** Bel, Y. (Valencia Univ. (Spain). Dept. of Genetics); Jacobson, K.B.; Ferre, J. Oak Ridge National Lab., TN (USA). [1989]. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. From 9. international symposium on pteridines and folic acids derivatives; Zurich (Switzerland); 3-8 Sep 1989. Order Number DE90003702. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The aim of the present work is the study of phenylalanine hydroxylase (PH) activity of Drosophila melanogaster wild type with different cofactors: the two natural occurring tetrahydropteridines (BH_4 and PH_4) and the synthetic 6,7-dimethyltetrahydropterin ($DMPH_4$), as well as the determination of this activity at different developmental stages. 7 refs., 2 figs.

8485 (DOE/ER/60742–2) **An immunochemical approach to the study of DNA damage and repair: Annual progress report, December 1, 1988–November 30, 1989.** Wallace, S.S. (Vermont Univ., Burlington, VT (USA). Dept. of Microbiology and Molecular Genetics); Erlanger, B.F. Vermont Univ., Burlington, VT (USA). Dept. of Microbiology and Molecular Genetics; Columbia Univ., New York, NY (USA). Dept. of Microbiology. [1989]. 12p. Sponsored by U.S. DOE Energy Research. DOE Contract FG02-88ER60742. Order Number DE90003347. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The most studied radiation-induced modified DNA base is thymine glycol. Thymine glycols are produced in relatively high yields in irradiated DNA and are also formed as a consequence of oxidative stress. Thymine glycol has been shown to be an in vitro replicative block to DNA polymerases as well as a cytotoxic lesion. DNA glycosylases that remove thymine glycol from damaged DNA are found in both prokaryotes an deukaryotes. Thus this lesion provides a good model for studying the potential biological consequences of pyrimidine ring saturation products. In order to elicit antibodies that would react with unique modified base on a damaged DNA molecule, we have chosen to chemically synthesize the hapten of interest and conjugate it to a protein carrier. Thymine glycol monophosphate was synthesized, conjugated by the carbodiimide method to bovine serum albumin (BSA), and used as an immunogen. Initially, polyclonal antibodies were produced in rabbits. These antibodies had high affinity and specificity as measured by both albumin (RSA) and by enzyme immunoassay using either the conjugate or DNA oxidized inhibited by thymine glycol, thymidine glycol and thymine glycol monophosphate determinants for the phosphate group in addition to the thymidine glycol. In both the direct and competitive assays, this antibody reacts with osmium tetroxide-treated DNA containing cis-thymine glycols and DNA X-irradiated in vitro at a femtomole level of sensitivity. 24 refs.

8486 **Genetic recombination: A brief overview. .** Low, K.B. (Radiobiology Labs., Yale Univ. School of Medicine, New Haven, CT (US)). pp. 506 of The recombinations of genetic material. Low, K.B. Academic Press Complimentary Copy Coordinator, Marketing Dept., San Diego, CA (1988).

Recombinational phenomena are by no means restricted to the crossing over between pairs of homologous chromosomes as in the examples mentioned above. As a result of much elegant and laborious work, a number of distinctly different types of events which involve chromosomal interactions have been observed, and in some cases a great deal is now known of their characteristics. Most fundamentally, these various types of recombination differ in the relationships of the series of four types of nitrogenous bases [adenine (A), cytosine (C), guanine (G), and thymine (T)] in the nucleic acid chains undergoing recombination.

8487 **Plant senescence: A proposed integration of the constituent processes.** Thimann, K.V. (Univ. of California, Santa Cruz (USA)). pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

An overview is presented of plant senescence, including senescence in seeds, leaves, roots, flowers and fruits. Attention is focused on senescence of leaves. The major characters of leaf senescence are outlined. The author proposes that while the cells are healthy, the membrane protein is sequestered from the proteases in some way and that senescence is initiated by a change in the structure of the tonoplast such that its proteins become exposed to the proteases. The result is that they are hydrolyzed and a gap is thereby formed in the tonoplast, through which the proteases flow out into the cytosol. There, more massive proteolysis results, and the proteases now attack the chloroplast membrane; they can then enter the chloroplast which, at least in oats, has extremely weak proteases of its own. As the thylakoid proteins are hydrolyzed, the chlorophyll becomes subject to the enzymatic attack that decolorized it. The proteases also attack the membrane of the mitochondria, which allows liberated amino acids to flow in and this causes the great increase in respiratory rate. Thus, this sequence accounts for the lapse of time between the observed onset of proteolysis and the loss of chlorophyll, as well as the delay before the respiratory rise occurs. The change in structure of the tonoplast membrane which allows the proteases to reach the cytosol would therefore be the initiating step in leaf senescence.

8488 **Ultrastructure and senescence in plants.** Thomson, W.W. (Univ. of California, Riverside (USA)); Platt-Aloia, K.A. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

In this article, we will focus on the high degree of order, i.e. compartmentation as defined by membranes, that is maintained within cells as the degradative events of senescence are occurring. We will develop the thesis that the maintenance of this compartmentation throughout senescence is essential for the ordered sequence of senescent events to occur and that fragmentation of this compartmentation, either through injury or at the terminus of the senescent processes, is a randomizing event causing the death of the cell. In developing his hypothesis, we will focus on three different organs: senescing cotyledons, leaves, and fruits. Also, some artifacts, often assumed to be ultrastructural changes associated with normal senescence, will be illustrated and discussed.

8489 **Mitochondrial genomic changes during senescence in fungi.** Cummings, D.J. (Univ. of Colorado School of Medicine, Denver (USA)); Domenico, J.M.; Turker, M.S. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

For this report, we will present the entire 2.5 Kbp sequence of the ψsen DNA plasmid. This plasmid arose following a senescent crisis of a hybrid race A(Mt) race s(N) longevity mutant. It is especially interesting to the concept of excision-amplification and gene rearrangements since it contains 1500 bp from the Eco7 3'-end region and 1009 bp from βsenDNA in Eco1. These regions are about 15

Kbp apart on the mt genome. In addition, it contains a 72 bp repeat present on each flank in Eco7 and βsenDNA. Finally, ψsenDNA also encompasses 34 senDNA and all the sMt DNAs.

8490 Genetic regulation of senescence in a tropical grass. Ambler, J.R. (Texas A & M Univ., College Station (USA)); Morgan, P.W.; Jordan, W.R. pp. 269 of Plant senescence: its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The authors have conducted studies comparing the cytokinin physiology of senescent and nonsenescent sorghums as first steps in understanding the genetic regulation of nonsenescence. Chlorophyll retention responses to kinetin applied to leaf disks from mature sorghum plants were measured. In other studies, cytokinin levels in xylem sap were analyzed with both mature, field-grown plants, and vegetative plants from a growth room. With this latter, in addition to controls, treatments of reduced nitrogen and light have been used to determine whether the lines respond differently under suboptimal conditions. A progress report on these studies is presented here.

8491 Proteolytic enzymes and leaf senescence. Dalling, M.J. (Calgene Pacific Pty. Ltd., Victoria (Australia)). pp. 269 of Plant senescence: its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Senescence, defined by the loss of RuBPCase, is accompanied by an increase in proteolysis. The term proteolysis is used carefully in this instance. For proteolysis to occur, it is necessary that the protein or peptide substrate by made accessible or acceptable to the hydrolyzing enzymes, i.e. the peptide hydrolases. In many respects, progress in understanding proteolysis has been delayed because of the failure of plant physiologists to appreciate the critical interdependence in situ of the protein substrate and the hydrolyzing enzymes. For the sake of simplicity, it is possible to distill this complex phenomenon down to three major components: Accessibility, Acceptability, and Activity. These three key concepts for modulation of proteolysis during senescence are discussed in detail.

8492 Protein turnover during senescence. Thayer, S.S. (Univ. of California, Davis (USA)); Choe, H.T.; Tang, A.; Huffaker, R.C. pp. 269 of Plant senescence: its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The turnover of protein is critical to the N and C economy of a plant during its reproductive development. Often, during the reproductive phase, leaf senescence simultaneously occurs. This is especially true of plants growing under conditions where N is a limiting nutrient to growth. In the wilds, N and water are usually the two most limiting factors to plant growth. During the reproductive phase, the stored protein in the plant is degraded and furnishes both N and C to the seed. Protein metabolism can change markedly when senescence begins, depending upon the specific protein being considered and its intracellular location. This paper is not meant as an inclusive review; rather, specific proteins in chloroplasts and cytoplasm will be referred to as examples.

8493 Mitochondrial activity during senescence. Romani, R.J. (Univ. of California, Davis (USA)). pp. 269 of Plant senescence: its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

In the more than 30 years since the pioneering study by Millerd et al. there have been numerous attempts to demonstrate a causal role for mitochondria in plant senescence. Much valuable information has accrued, but none has demonstrated the sought for cause-effect relationship. After noting evidence compelling one to believe that mitochondria are especially active in senescent plant cells, I will briefly review some key studies that have addressed the question of mitochondrial activity and senescence, and then offer a few data and arguments that imply not a causative, but a reactive, role for mitochondria in senescent plant cells.

8494 Polygalacturonase: its importance and regulation in fruit ripening. Bennett, A.B. (Univ. of California, Davis (USA)); DellaPenna, D. pp. 269 of Plant senescence: its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

One of the most profound events in fruit development is the ripening process. Ripening is comprised of a series of metabolic transitions that collectively modify fruit texture, flavor, and color. The ripening process is also considered to initiate the sequence of metabolic events which eventually lead to senescence of the fruit. Underlying the obvious changes associated with ripening are numerous biochemical changes and changes in gene expression that presumably contribute to the coordinated transitions in metabolism. While ethylene is the most important factor initiating the ripening process, interactions of ripening-induced gene products may provide further levels of regulation. In this paper we will review: (i) evidence supporting the role(s) of PG in fruit softening and ripening; (ii) molecular cloning of PG; and (iii) regulation of PG expression during ripening.

8495 Comparison of soybean pigment-protein complexes during development and senescence. Eskins, K. (Department of Agriculture, Peoria, IL (USA)); McCarthy, S. pp. 269 of Plant senescence: its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Pigment-protein complexes are intimately involved in the photosynthetic processes carried out in plant chloroplasts. These complexes of chlorophylls and carotenoids with proteins function as both light-harvesting and light-processing centers. During early development, the initial synthesis of these complexes is controlled by developmental genes, light quality, light intensity, temperature, and other environmental factors. Senescence of pigment-protein complexes is also an energy-requiring process in which the sequence of events may be cued by light interacting with the genetic machinery. In this paper, we have chosen to explore first the genetic component of these controlling factors in a system where changes in development or senescence are characteristic of a particular genotype. We have also compared the synthesis of these complexes during early development with their destruction during normal aging and senescence. We have attempted to differentiate the effects of leaf and plant age. Such comparisons will be helpful in determining the nature of long-term gene expression such as that found throughout development and senescence.

8496 Metabolism of thylakoid membrane proteins during foliar senescence. Thomas, H. (Welsh Plant Breeding Station, Dyfed (England)); Hilditch, P. pp. 269 of Plant senescence: its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The thylakoid membrane is constructed of multi-component complexes embedded in a fluid (largely glyco-) lipid bilayer. The complexes are: PSII, with associated water-splitting site, and the major chlorophyll protein LHC2; the cytochrome b_6/f complex; PSI; and coupling factor ATPase comprising CF_0 and CF_1 components. The complexes communicate with each other through diffusible, low mol wt intermediates. Plastoquinone (PQ) transports electrons between PSII and the cytochromes. Plastocyanin carries electrons from the cytochromes to PSI. Chemiosmotic ATP synthesis by coupling factor is driven by protons transported from the stroma to the lumen during the PQ oxidation-reduction cycle, and produced by the photolysis of water. The complexes are nonrandomly distributed

throughout the membrane, with PSII and LHC2 more abundant in the appressed regions. We describe here the behavior of components of the latter complexes during senescence of normal and mutant Festuca leaf tissue.

8497 **Carbon fixation and changes with senescence in rice leaves.** Mae, Tadahiko (Tohoku Univ., Sendai (Japan)); Makino, Amane; Ohira, Koji. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Leaf photosynthesis shows large changes with leaf age. As the leaf grows and chloroplasts are assembled, photosynthetic activity rapidly increases to a maximum rate just after full expansion. Thereafter, the leaf steadily loses its photosynthetic capacity during senescence. Changes in the activities of stromal enzymes or electron transport in relation to photosynthesis have been studied during senescence in various higher plants. These parameters also exhibit a large change similar to that of photosynthesis with leaf age; however, the factors responsible for the changes in photosynthesis have yet to be elucidated. In this study, we tried to clarify the factors responsible for the changes in photosynthesis with leaf age in rice. Changes in the apparent rates of CO_2 assimilation under ambient air conditions, were determined quantitatively in rice leaves from the changes in two factors limiting photosynthesis, i.e. carboxylation/oxygenation and regeneration of RuBP, during reproductive stages.

8498 **Regulation of senescence in the chloroplast.** Woolhouse, H.W. (John Innes Institute, Norwich (England)). pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The author discusses chloroplast senescence in the context of the nutrient economy of the plant. The role of the nucleus in the regulation of chloroplast senescence and the signaling relationships of the nucleus, plastids, and cytoplasm are presented. The decline of photosynthetic capacity which accompanies the ultrastructural changes in the chloroplasts of senescing leaves is analyzed. The process is examined by which the chloroplast is assembled in the course of its development and the way in which it is dismantled in the course of its senescence. Finally, some of the problems involved in chloroplast senescence are discussed.

8499 **The involvement of activated oxygen in membrane deterioration during senescence.** Thompson, J.E. (Univ. of Waterloo, Ontario (Canada)); Paliyath, G.; Brown, J.H.; Duxbury, C.L. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

As plant tissues senesce, there is a progressive loss of membrane bilayer integrity resulting in increased leakage of solutes and loss of specialized membrane functions. There is increasing evidence that free radical-induced lipid peroxidation contributes to this deterioration. Peroxidized lipids accumulate in senescing membranes, and there is a strong temporal correlation between lipid peroxidation and increased membrane permeability with advancing senescence. In this presentation, evidence indicating that lipoxgenase associated with senescing membranes produces activated oxygen and is able to initiate lipid peroxidation is documented. As well, prospective mechanisms for generating fatty acid substrates for lipoxygenase in senescing tissues are examined.

8500 **The role of ethylene and ethylene synthesis in fruit ripening.** Yang, S.F. (Univ. of California, Davis (USA)). pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Smoke as an agent to hasten the ripening of fruits was recognized a long time ago. This effect is now attributed to the action of ethylene that is present in the smoke. In 1924, Denny determined that the effect of stove gas that induced the yellowing of lemons could be duplicated if ethylene replaced stove gas. By 1930, ethylene was recognized to have a wide variety of interesting effects on plant. It was not until 1934, however, that Gane presented chemical proof that ethylene was a natural plant product. Shortly thereafter, scientists proposed that ethylene is a plant hormone capable of initiating fruit ripening. In this report I shall focus my discussion on the role of ethylene on ethylene biosynthesis, and on the relationship between ethylene synthesis and the initiation of fruit ripening.

8501 **Polyamines and senescence in plants.** Galston, A.W. (Yale Univ., New Haven, CT (USA)); K-Sawhney, R. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The evidence relating declining polyamines (PAs) titer to the onset of senescence in excised, darkened leaf segments is as follows: Both arginine decarboxylase activity and PA titer decline as senescence begins. The application of exogenous PAs inhibits or delays senescence. Exogenous PAs also affect individual processes known to be associated with the onset of senescence, such as the biosynthesis and action of ethylene, ribonuclease and proteases, and the uptake and transport of calcium. Transferring the leaves to white light substantially retards senescence. Such light also increases arginine decarboxylase activity and PA titer. While this evidence is mainly correlational, it seems as substantial and convincing as the evidence for other substances or processes suggested as regulating senescence. The known effects of PAs on membrane properties, on nucleic acids and on calcium uptake and transport provide a possible framework for understanding the mechanism of PA action in the excised leaf system. Whether PAs are involved in the senescence of other organs or of entire plants remains for future investigations to reveal.

8502 **The role of calcium and calmodulin in senescence.** Poovaiah, B.W. (Washington State Univ., Pullman (USA)). pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The effects of calcium on various parameters of senescence, such as loss of chlorophyll and protein, increased membrane leakage, dissolution of the middle lamella, and associated changes in the cell wall, are well established. However, only recently have the investigations on calmodulin and phosphoinositides revolutionized our thinking about the overall significance of calcium in various physiological responses in plant. It is now clear that calcium plays a central role in cellular regulation in both plants and animals. The discovery of various components of the calcium messenger system, such as calmodulin and calmodulin-dependent enzymes, has led to plant physiologist to suggest a messenger role for calcium in mediating physiological changes. It has become clear that calcium is not simply a macronutrient, but that the changes in cytoplasmic-free calcium concentration can have immense effects on almost all aspects of cell function. Various aspects of the involvement of calcium in senescence have been recently reviewed.

8503 **Biochemical changes in stressed and senescent soybean root nodules.** Wagner, F.W. (Univ. of Nebraska, Lincoln (USA)); Sarath, G. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The study of root nodule senescence is not practical with field-grown soybeans because of the complexity of measuring nitrogen fixation, the uncertainty of soil nitrogen levels, and the difficulty in harvesting nodules. With plants grown in nitrogen-free potting material under controlled conditions of temperature, light, and humidity,

these complications are avoided; however, others prevail including the uncertainty of nodule age in older plants, and susceptibility of aged plants to infection and predators. For these reasons, we have used dark stress to induce into healthy plants, with more uniform nodule populations, a degradative state which mimics natural senescence. We present here a summary of results obtained by studying this system and correlate them to corresponding measurements made using nodules from naturally senescing plants.

8504 Stomata in senescing leaves: Guard cell viability and regulation of stomatal function in Nicotiana glauca. Heaton, T. (Pepperdine Univ., Malibu, CA (USA)); Lee, A.; Tallman, G. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

A comparison of stomatal action and guard cell viability and metabolism in senescing and nonsenescing leaves may provide us with insights into how stomata are regulated, how that regulation changes as leaves age and senesce, and perhaps how the senescence process is induced. In this chapter, we discuss guard cell viability and regulation of stomatal function in senescing leaves of the perennial plant, Nicotiana glauca. We examine our rationale for studying this plant, we review the evidence that guard cells in senescing leaves are viable, and we introduce preliminary data regarding the nature of stomatal regulation in senescing leaves. Finally, we offer further questions and experimental directions for the reader's consideration.

8505 Purification of seven peptidases from soybean root nodules. Sarath, G. (Univ. of Nebraska, Lincoln (USA)); Wagner, F.W. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Seven peptidases were purified simultaneously from the plant cytosolic fraction of soybean root nodules. Based on the hydrolysis of artificial aminoacyl substrates, four were characterized as endopeptidases (EPs) and three as aminopeptidases (APs). All seven enzymes appear to be monomeric with acidic isoelectric points. The APs show a pI around 4.3, while the EPs are clustered around 4.7. The EPs can also be distinguished from each other by their substrate specifications and by their behavior on hydroxylapatite (HAPT). EP-1 does not bind to HAPT equilibrated with 10 mM phosphate, pH 6.8. All the other EPs bind to HAPT and can be eluted with 300 mM phosphate, pH 6.8. EP-4 appears to be glycoprotein since it binds to Concanavalin-A-Sepharose. We have also identified another EP fraction (EP-5) that shows activity against benzoyl-L-alanine-β-nitroanilide. EP-1, EP-2, EP-3, and EP-4 constitute approximately 39%, 33%, 5%, and 23% of the total benzoyl-arginyl-β-naphtylamide hydrolyzing activity of the crude extracts, respectively. The EPs appear to have a serine in their active site. and exhibit a pH optimum between 8 to 9. The APs hydrolyze a variety of L-aminoacyl-naphthylamide substrates.

8506 Senescence and vascular blockage of detached plant parts. van Doorn, W.G. (Sprenger Institute, Wageningen (Netherlands)); Reid, M.S. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Plant senescence is frequently studied in detached systems, such as leaf discs, and explants. In cut flowers, wilting commonly is considered as a symptom of senescence, but may simply reflect an inability of the stem to conduct water. Since unfavorable water relations may influence senescence processes, we have examined some factors influencing the water relations of cut flowers of two rose cultivars (Rosa hybrida cvs Sonia and Cara Mia). Although flowers of both cultivars took up about 50 μl of air in the first 10 min after cutting, they differed in their ability to bypass the resulting emboli when they were placed in water. Sonia roses showed a large transitory increase in water uptake, after which uptake continued at a substantial rate. In Cara Mia flowers, water conductivity remained below the rate of transpiration, which explains why flowers of this cultivar often wilt rapidly. If their stems were recut under water, Cara Mia flowers showed a similar uptake pattern to that of Sonia flowers. During a study of extended a water relations in Sonia flowers, it was found that stem water conductivity fell as bacteria populations in the stem increased. Bacteria were largely confined to the lower 5 cm of the stem. Micrographs showed plugging of vessels and vessel pits by bacteria and by bacterial products in such flowers.

8507 Changes in gene expression during carnation petal senescence. Woodson, W.R. (Purdue Univ., West Lafayette, IN (USA)). pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The senescence of carnation (Dianthus caryophyllus L. cv White Sim) flower petals is associated with a wide range of biochemical changes. Most notable among these changes is the climacteric increase in respiration and ethylene production. The means by which flower petal senescence is coordinated and regulated are unknown. They have been studying the possibility that petal senescence is controlled, at least partially, at the transcriptional and translational level. Total proteins were extracted from petals isolated from carnation flowers during senescence following harvest and separated by SDS-PAGE. Analysis of the Coomassie blue-stained gel revealed several polypeptides decrease during aging. In addition, two polypeptides, with apparent mol wt of 76 and 64 kD, were present in petals only during and following the ethylene climacteric. Total RNA declined with petal senescence. In contrast, the highest level of poly(A)$^+$RNA was associated with the ethylene climacteric and the onset of senescence. Changes in mRNA populations during senescence were investigated by translating poly(A)$^+$RNA in vitro using the rabbit reticulocyte lysate system. Polypeptides synthesized in vitro were separated by one- and two-dimensional gel electrophoresis and visualized by fluorography.

8508 Acceleration of senescence processes in wheat by high temperatures. Ferguson, D.L. (Kansas State Univ., Manhattan (USA)); Harding, S.A.; Paulsen, G.M. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Senescence of wheat and other temperate cereals is strongly influenced by ambient temperature after anthesis: little visible senescence occurs below 20°C until physiological maturity, whereas processes accelerate markedly as temperature increases above 20°C. Acceleration of senescence by high temperatures is of scientific interest because plant metabolism is altered, and of practical concern because cereal yield is a function of leaf area duration. Objectives of their research are to determine the mechanism of acceleration of senescence processes by high temperature and to identify germplasm that is resistant to the phenomenon.

8509 Cellular deterioration induced by accelerated aging in sunflower seeds. Gidrol, X. (I.N.R.A., Pont de la Maye (France)); Noubhani, A.; Mocquot, B.; Pradet, A.; Serghini, H.; Mazliak, P. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Sunflower seeds (Helianthus annuus, var Rodeo) were submitted to accelerated aging from 1 to 7 d. The authors investigated cellular deterioration at membrane and nucleic acid levels. Depending on the time spent under accelerated aging conditions, they observed a large decrease of translatable RNA extracted from dry seeds. The behavior of seeds submitted to accelerated aging was also studied after 12 h of imbibition; the greater the time spent under accelerated aging conditions, the lower the neo-synthesis of mRNAs, as shown by SDS-PAGE analyses of cell-free translation products.

During the accelerated aging, membrane damaged were observed, as demonstrate by the increase of seed leakage and lipid peroxidation products. However, the lipid peroxidation process seems to concern the reserve lipids rather than those of the biomembranes. These results suggest the involvement of oxidative phenomena in the accelerated aging process, leading to reduced germinability.

8510 Leaf senescence and chlorophyll degradation: Does galactolipid hydrolysis activate chlorophyll-bleaching?. O'Sullivan, J.N. (Univ. of Melbourne, Parkville (Australia)); Wardley, T.M.; Dalling, M.J. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

A causal link has been established in vitro between the autonomous ability of thylakoid membranes to hydrolyze galactolipids and the initiation of chlorophyll-bleaching. The galactolipase activity has been studied in the thylakoids from primary leaves of wheat. It partially hydrolyzes monogalactosyl diacylglycerol (MGDG), generating a lysolipid and free linolenic acid (LNA). The hydrolysis is extremely active at pH 6.0, but rapidly reaches an endpoint after about half the thylakoid MGDG has been hydrolyzed. It is not inhibited by the liberated fatty acids, as they can be removed from the membranes by the inclusion of BSA, without affecting the course of galactolipid hydrolysis. Chlorophyll Oxidase (CHLOX) is a chlorophyll-bleaching activity that has recently been characterized in the thylakoids from barley. It may be a nonenzymatic property of the photosystem complexes. It is activated in the presence of free polyunsaturated fatty acids, particularly LNA. They have found that the LNA released by the thylakoid's endogenous galactolipid-hydrolyzing activity is effective in activating the CHLOX activity. This reveals an autonomous system within chloroplasts which may explain the parallel and interdependent decline in chlorophyll and galactolipids during leaf senescence.

8511 Inability to activate nucleoli in quiescent, senescing cells of Allium cepa using plant growth regulators. Karagiannis, C.S. (Southern Illinois Univ., Carbondale (USA)); Pappelis, A.J. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Nuclei and nucleoli in quiescent turgid leaf bases of stored onion bulbs become activated when the leaf base tissue is exposed to the ambient atmosphere. Nucleoli increase in size and change in morphology through the following shapes sequentially: round (R), oval (O), elongate-oval (EO), and dumbbell (DB). It was inferred that since there are two ribosomal cistron (rc) types in onion that differ in the nucleotide sequences of the external spacer, specific inhibitors and activators occur for each type and that the two types of rcs function separately during cell growth, differentiation, cell division, and senescence. The authors refer to this as selective rc regulation. Six plant growth regulators were tested with basal, equatorial, near apical, and apical tissue incubated in the light and dark. Nucleoli were viewed by interference microscopy, number per nucleus recorded, and type scored. The nucleolar score for each location was obtained by adding nucleolar values for all nucleoli per 20 nuclei evaluated per location.

8512 The role of fructose 2,6-bisphosphate and selected glycolytic enzymes in the ripening of banana fruit. Beaudry, R.M. (Univ. of Georgia, Athens (USA)); Paz, N.; Black, C.C.; Kays, S.J. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

In ripening banana (Musa acuminata L. cv Valery) fruit, the concentration of the glycolytic regulator fructose 2,6-bisphosphate (fru 2,6-P_2) under went a transient increase 2 to 3 h before the respiratory rise, but coincident with the increase in ethylene synthesis. Fru 2,6-P_2 concentration increased again approximately 1 d after the initiation of the respiratory climacteric, and continued to increase as ripening proceeded. Pyrophosphate-dependent phosphofructokinase (PPi-PFK) activity appeared to undergo a general decline following the onset of ripening. Cytosolic fructose 1,6-bisphosphate (FBPase) activity did not change appreciably throughout the ripening process. An increase in the activity of ATP-dependent phosphofructokinase (ATP-PFK) occurred 2 to 3 h prior to the respiratory rise. Propylene pretreatment induced an increase in fru 2,6-P_2, and changes in peel color associated with ripening under hypobaric conditions, which reduced internal ethylene levels five-fold.

8513 In vivo NMR spectroscopy of ripening avocado. Bennett, A.B. (Univ. of California, Davis (USA)); Smith, G.M.; Nichols, B. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Ripening of avocado fruit is associated with a dramatic increase in respiration. Previous studies have indicated that the increase in respiration is brought about by activation of the glycolytic reaction catalyzing the conversion of fructose-6-phosphate to fructose 1,6-bisphosphate. The authors reinvestigated the proposed role of glycolytic regulation in the respiratory increase using in vivo ^{31}P nuclear magnetic resonance (NMR) spectroscopy using an external surface coil and analysis of phosphofructokinase (PFK), phosphofructophosphotransferase (PFP), and fructose 2,6-bisphosphate (fru 2,6-P_2) levels in ripening avocado fruit. In vivo ^{31}P NMR spectroscopy revealed large increases in ATP levels accompanying the increase in respiration. Both glycolytic enzymes, PFK and PFP, were present in avocado fruit, with the latter activity being highly stimulated by fru 2,6-P_2. Fructose 2,6-bisphosphate levels increased approximately 90% at the onset of ripening, indicating that the respiratory increase in ripening avocado may be regulated by the activation of PFP brought about by an increase in fru 2,6-P_2.

8514 The production and involvement of ethylene during the disease process of Alternaria stem canker of tomato. Moussatos, V.V. (Univ. of California, Davis (USA)); Gilchrist, D.G. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The AAL-toxins, produced by Alternaria alternata f. sp. lycopersici during the stem canker disease, induce an increase in ethylene evolution from F9 isogenic tomato (Lycopersicon esculentum) leaflets selected for susceptibility to AAL-toxin. This increase in ethylene evolution occurs approximately 24 h after AAl-toxin application and 10 to 30 h prior to the AAL-toxin induced necrosis appearance. Repression, inactivation, or delay of this increase in ethylene evolution, using specific ethylene biosynthesis inhibitors, resulted in the same effect on AAL-toxin induced necrosis. ACC synthase inhibitors used were aminoethoxyvinyl glycine (AVG), and aminooxyacetic acid (AOA). Ethylene forming enzyme (EFE) inhibitor, cobaltous chloride, was used. Ethylene activity inhibitors, silver nitrate and silver thiosulfate, were also used. Whereas specific inhibitors repressed AAL-toxin induced necrosis, addition of the immediate ethylene precursor, 1-aminocyclopropane 1-carboxylic acid (ACC), enhanced AAL-toxin induced necrosis. However, addition of ACC without AAL-toxin did not result in necrosis.

8515 Nucleases and ribonucleases in senescing wheat leaves. Blank, A.S. (Dept. of Agriculture, Albany, CA (USA)); McKeon, T.A. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

It has been widely reported that leaf senescence is accompanied by an increase in nucleolytic activity. The work reported here is focused on determining which of the leaf-tissue nucleases or ribonucleases contribute to the increase in nucleolytic activity and, thus, may play a role in wheat (Chinese Spring) leaf senescence.

The authors have used activity-straining after SDS-PAGE to enumerate electrophoretically-distinct nucleases and ribonucleases present in the leaf tissue of seedlings. By varying buffers, pH, ionic strength and substrate, they can distinguish four major groups of nucleolytic enzymes in gels. Four single-strand preferring nuclease isozymes (33-37K); RNase WL-B, a group of catalytically-related ribonucleases having activity at both acid and alkaline pH (24 to 28K, main activity 26K); RNase WL-C, an alkaline ribonuclease (27K); and RNase WL-A, an acid ribonuclease 920 K. The activity profiles of the four activity groups during senescence suggests that wheat-leaf senescence involves differential expression of the isozyme groups present in nonsenescent leaves. Of these activities, the group of nucleases have a development profile closely corresponding to that of senescence, and thus may be involved in the mediation of leaf senescence.

8516 **Differences between wheat and rice in the enzymic properties of ribulose-1,5-bisphosphate carboxylase/oxygenase and the relationship to photosynthesis.** Makino, Amane (Tohoku Univ., Sendai (Japan)); Mae, Tadahiko; Ohira, Koji. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The kinetic parameters of RuBP carboxylase/oxygenase in wheat (Triticum aestivum L.) and rice (Oryza sativa L.) were determined by rapidly assaying the leaf extracts. The respective K_m and V_{max} values were significantly higher from wheat than from rice. The net activity of CO_2 exchange estimated at the physiological CO_2/O_2 concentrations from these kinetic parameters was 22% greater in wheat than in rice. This difference in the in vitro RuBP carboxylase/oxygenase activity between two species reflected a difference in the CO_2-assimilation rate per unit of RuBP-carboxylase content. However, this difference in the kinetic parameters was offset by the differences in RuBP-carboxylase content and conductance. Consequently, there was no apparent difference in the CO_2-assimilation rate for a given nitrogen content. The estimated RuBP carboxylase/oxygenase activity as the intercellular CO_2 pressure was linearly correlated to the rate of CO_2 assimilation. In addition, these activities in wheat and rice were similar to each other for the same rate of CO_2 assimilation.

8517 **Protease nomenclature.** Storey, R. (Colorado College, Colorado Springs (USA)); Sarath, G.; Wagner, F.W. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Protease and peptidase are synonymous as the class name for peptide hydrolases, enzymes which hydrolyze peptide bonds. Endopeptidases (EP), or proteinases, cleave internal peptide bonds, while aminopeptidases (AP) cleave single amino acids from the α-NH_2 terminus, and carboxypeptidases (CP) cleave single amino acids from the α-COOH terminus, of proteins and peptides. They suggest dipeptidyl aminopeptidase and dipeptidyl carboxypeptidase as the names for enzymes that remove dipeptides from the amino- and carboxy-terminal end of peptide chains, respectively. Finally, dipeptidases convert dipeptides to amino acids, and tripeptidases convert tripeptides to a dipeptide and an amino acid. Only specific model substrates can be used to classify and characterize a protease. EP are assigned to a mechanistic set - serine, cysteine, aspartic acid, and metalloproteinases - using a range of diagnostic inhibitors. They suggest the other proteases also be assigned to a mechanistic set according to their inhibitor response.

8518 **Effect of mechanical perturbation on foliar senescence.** Giridhar, G. (Wake Forest Univ., Winston-Salem, NC (USA)); Jaffe, M.J. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The influence of mechanical perturbation (MP, gentle rubbing) on leaf senescence was studied with special reference to oat leaf segments. Rubbing promoted the loss of both chlorophyll and proteins by oat leaf segments kept in the dark, and the rate of increase was roughly proportional to the number of rubbings made on the leaf segments. The promotion of senescence, due to MP, could be seen within 24 h of dark incubation, and continued throughout the experimental period. With two exceptions, different senescence inhibitors and promoters acted similarly on both control and MP leaf segments, but the amount of chlorophyll and proteins was always less in the rubbed leaf segments than their respective control segments, thus maintaining the MP effect. With cycloheximide, the inhibitory effect was actually enhanced by rubbing, and thus MP-treated segments retained more chlorophyll and proteins than the controls. Spermine inhibited the MP effect. Similar promotion of senescence by MP was observed on attached leaves of cocklebur, oats, beans, soy beans, and pumpkin seedlings. The significance of mechanical perturbation on promoting foliar senescence, and its interaction with other senescence-modifying substances, will be discussed.

8519 **Analysis of plasma membrane enriched fractions from ripening avocado fruits.** Dallman, T.F. (Univ. of California, Riverside (USA)); Eaks, I.L.; Thomson, W.W.; Nothnagel, E.A. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Plasma membrane-enriched fractions isolated from mesocarp tissue of avocado fruit (Persea americana Mill. var Hass) at three different stages of ripening have been examined. Plasma membrane activity ($VO_4^{=}$ sensitive ATPase specific activity) in the enriched fractions was increased more than three-fold, relative to total membrane fractions. The peak fraction of $VO_4^{=}$ sensitive ATPase total activity increased in buoyant density from 1.15 g/cm^3 for fresh-picked fruit to 1.17 g/cm^3 for fruit sampled during the peak and declining portions of the respiratory climacteric that delineates avocado fruit ripening. Preliminary lipid analysis of plasma membrane-enriched fractions show no differences in phospholipid or sterol levels during ripening. Protease activity of the enriched plasma membrane fraction was relatively low, and did not change during ripening. Characteristic changes din the electrophoretic banding pattern of polypeptides from the plasma membrane-enriched fractions during ripening include increases in the relative abundances of 50 kD and 36 kD polypeptides, and a decrease in the relative abundance of a 26 kD polypeptide. Western blot hybridization of cellulase antibody show that the increase of the 50 kD polypeptide during ripening is due, at least in part, to the development expression of cellulase.

8520 **Light harvesting in senescing Panicum miliaceum Linn.** Lyon, J.L. (Univ. of California, Riverside (USA)); Nothnagel, E.A. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The goal of this project is to discuss the maintenance of light-harvesting capacity during senescence through measurements of the excitation spectrum of chlorophyll fluorescence in thylakoid membranes. For this work, proso millet (Panicum miliaceum Linn.) plants were grown in soil in one-gallon pots in a greenhouse. After heading had occurred, water was withheld to accelerate leaf senescence. Thylakoid membranes were isolated from the lower leaves at selected time intervals during senescence. As total chlorophyll in the thylakoids declined, the chlorophyll a:chlorophyll b ratio decreased slightly, while the total chlorophyll:carotenoid ratio dropped more rapidly. The 670 nm wavelength region of the excitation spectrum of chlorophyll fluorescence in thylakoids exhibited small changes with senescence that were consistent with the small decrease in the chlorophyll a:chlorophyll b ratio. A slight relative increase in excitation, around 475 to 490 nm for chlorophyll fluorescence, was also observed during senescence, but this increase was far less than proportional to the increase in the

carotenoid:chlorophyll ratio. The ineffectiveness of the excess carotenoids in light harvesting may be due to carotenoid accumulation in the plastoglobuli during senescence.

8521 Characterization and subcellular localization of aminopeptidase in senescing barley leaves. Thayer, S.S. (Univ. of California, Davis (USA)); Choe, H.T.; Huffaker, R.C. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Aminopeptidase (AP) activities in intact primary leaves of barley decreased up to 60% between day 7 and day 14, and another 30% between days 14 and 21. Based on eight artificial substrates, aminoacyl-β-Naphthylamides (aa-β-NA) used, the decreasing order of AP activities remaining in the leaves were: Phenyl (1), 67 μM h^{-1} g^{-1} fresh weight, followed by tyrosine (2), leucine (3), alanine (4), methionine (5), arginine (6), serine (7), and valine (8) at 0.61 μM h^{-1} g^{-1} fresh weight. Four aminopeptidases were separated from crude homogenates on 7.5% PAGE, and designated AP1, AP2, AP3, and AP4, according to R_m values. AP2, AP3, and AP4 were found in the stroma. No AP activity was detected in the vacuoles of these leaves. Approximately 50% of the AP activity is located in the chloroplasts. No new APs appeared on gels during senescence, and none disappeared. AP1, AP3, and AP4 showed a fairly broad range of substrate specificity, whereas AP2 hydrolyzed only Arg-β-NA. The APs found in the stroma have the same substrate specificities as those in the crude homogenate. The mol wt of AP2, AP3, and AP4, as calculated in native gels according to Hedrick and Smith were 66.7, 56.5, 54.6 kD, respectively.

8522 A hydrogenase-linked gene in Methanobacterium thermoautotrophicum strain α encodes a polyferredoxin. Reeve, J.N. (Ohio State Univ., Columbus (USA)); Beckler, G.S.; Cram, D.S.; Hamilton, P.T.; Brown, J.W.; Krzycki, J.A.; Kolodziej, A.F.; Alex, L.; Orme-Johnson, W.H.; Walsh, C.T. *Proceedings of the National Academy of Sciences of the United States of America (USA),* 86(9): 3031-3035 (May 1989).

The genes mvhDGA, which encode the subunit polypeptides of the methyl viologen-reducing hydrogenase in Methanobacterium thermoautotrophicum strain ΔH, have been cloned and sequenced. These genes, together with a fourth open reading frame designated mvhB, are tightly linked and appear to form an operon that is transcribed starting 42 base pairs upstream of mvhD. The organization and sequences of the mvhG and mvhA genes indicate a common evolutionary ancestry with genes encoding the small and large subunits of hydrogenases in eubacterial species. The product of the mvhB gene is predicted to contain six tandomly repeated bacterial-ferredoxin-like domains and, therefore, is predicted to be a polyferredoxin that could contain as many as 48 iron atoms in 12 Fe_4S_4 clusters.

8523 A second exopolysaccharide of Rhizobium meliloti strain SU47 that can function in root nodule invasion. Zhan, Hangjun (Univ. of Washington, Seattle (USA)); Levery, S.B.; Lee, C.C.; Leigh, J.A. *Proceedings of the National Academy of Sciences of the United States of America (USA),* 86(9): 3055-3059 (May 1989). DOE Contract FG06-86ER13532.

Rhizobium meliloti strain SU47 produces the calcofluor-binding exopolysaccharide, succinoglycan, that is required for alfalfa root nodule invasion. Strains derived from R. meliloti SU47 secreted an acidic exopolysaccharide, EPSb, that replaced succinoglycan in nodule invasion. EPSb, which has not formerly been identified among the Rhizobiaceae, consisted of the repeating unit 4,6-O-(1-carboxyethylidene)-α-D-Galp1$\rightarrow$3(X-O-Ac)-β-D-Glcp1$\rightarrow$3 EPSb synthesis occurred either in strains containing a mutation in a locus designated mucR or in strains with a recombinant cosmid pMuc. mucR mapped slightly counterclockwise from pyr49 on the chromosome, while pMuc contained genes mapping to the megaplasmid pRmeSU47b. In exc-A, -F, and -H mutants, which are deficient in normal succinoglycan secretion and nodule invasion, a transposon Tn5 insertion in mucR or the presence of pMuc resulted in EPSb secretion and a restoration of nodule invasion on Medicago sativa and Melilotus alba. Mutants in exoB and exoC were incapable of succinoglycan and EPSb secretion as well as nodule invasion. A mutant that secreted succinoglycan but was incapable of EPSb secretion invaded nodules normally.

8524 Single-molecule fluorescence detection: Autocorrelation criterion and experimental realization with phycoerythrin. Peck, K. (Univ. of California, Berkeley (USA)); Stryer, L.; Glazer, A.N.; Mathies, R.A. *Proceedings of the National Academy of Sciences of the United States of America (USA),* 86(11): 4087-4091 (Jun 1989).

A theory for single-molecule fluorescence detection is developed and then used to analyze data from subpicomolar solutions of B-phycoerythrin (PE). The distribution of detected counts is the convolution of a Poissonian continuous background with bursts arising from the passage of individual fluorophores through the focused laser beam. The autocorrelation function reveals single-molecule events and provides a criterion for optimizing experimental parameters. The transit time of fluorescent molecules through the 120-fl imaged volume was 800 μs. The optimal laser power gave an incident intensity of 1.8×10^{23} photo-cm^{minus2}-s^{-1}, corresponding to a mean time of 1.1 ns between absorptions. The mean incremental count rate was 1.5 per 100 μs for PE monomers and 3.0 for PE dimers above a background count rate of 1.0. The distribution of counts and the autocorrelation function for 200 fM monomer and 100 fM dimer demonstrate that single-molecule detection was achieved. At this concentration, the mean occupancy was 0.014 monomer molecules in the probed volume. A hard-wired version of this detection system was used to measure the concentration of PE down to 1 fM. This single-molecule counter is 3 orders of magnitude more sensitive than conventional fluorescence detection systems.

8525 Structure of a second crystal form of Bence-Jones protein Loc: Strikingly different domain associations in two crystal forms of a single protein. Schiffer, M. (Argonne National Laboratory, IL (USA)); Ainsworth, C.; Xu, Z.B.; Carperos, W.; Olsen, K.; Solomon, A.; Stevens, F.J.; Chang, C.H. *Biochemistry (USA),* 28(9): 4066-4072 (2 May 1989).

The authors have determined the structure of the immunoglobulin light-chain dimer Loc in a second crystal form that was grown from distilled water. The crystal structure was determined to 2.8-Å resolution; the R factor is 0.22. The two variable domains are related by local 2-fold axes and form an antigen binding pocket. The variable domain-variable domain interaction observed in this crystal form differs from the one exhibited by the protein when crystallized from ammonium sulfate in which the two variable domains formed a protrusion. The structure attained in the distilled water crystals is similar to, but not identical with, the one observed for the Mcg light-chain dimer in crystals grown from ammonium sulfate. Thus, two strikingly different structures were attained by this multisubunit protein in crystals grown under two different, commonly used, crystallization techniques. The quaternary interactions exhibited by the protein in the two crystal forms are sufficiently different to suggest fundamentally different interpretations of the structural basis for the function of this protein. This observation may have general implications regarding the use of single crystallographic determinations for detailed identification of structural and functional relationships. On the other hand, proteins whose structures can be altered by manipulation of crystallization conditions may provide useful systems for study of fundamental structural chemistry.

8526 Nickel is required for the transfer of electrons from carbon monoxide to the iron-sulfur center(s) of carbon monoxide dehydrogenase from Rhodospirillum rubrum. Ensign, S.A. (Univ. of Wisconsin, Madison (USA)); Bonam, D.; Ludden, P.W. *Biochemistry (USA),* 28(12): 4968-4973 (13 Jun 1989). DOE Contract FG02-87ER13691.

The role of nickel in CO oxidation and electron flow was investigated in carbon monoxide dihydrogenase from Rhodospirillum rubrum. The Fe-S center of oxidized, nickel-containing (holo) CO dehydrogenase were completely reduced within 1 min of exposure to CO. The Fe-S centers of oxidized, nickel-deficient (apo) CO dehydrogenase were not reduced during a 35-min incubation in the presence of CO. Apo-CO dehydrogenase Fe-S centers were reduced by dithionite. The Fe-S centers of cyanide-inhibited, holo-CO dehydrogenase were not reduced in the presence of CO but were reduced by dithionite. Treatment of apo-CO dehydrogenase with cobalt(II), zinc(II), and iron(II) resulted in association of these metal

ions (0.70, 1.2, and 0.86 mol of M^{2+}/mol, respectively) with the protein but no increase in specific activity. Purified holo-CO dehydrogenase contained 1.1 mol of nickel/mol of protein and could not be further activated upon addition of $NiCl_2$, suggesting the presence of one catalytic nickel site on the enzyme. The M^{2+}-treated enzymes could not be further activated by addition of $NiCl_2$ as opposed to the untreated apoenzyme, whose activity was stimulated 50-100-fold to the level of holoenzyme upon addition of $NiCl_2$. When placed under CO, the Fe-S centers of the cobalt-treated enzyme became reduced over a 35-min time course, as opposed to the zinc- and iron-treated enzymes, which remained oxidized. The authors conclude that nickel, or an appropriate nickel analogue in the nickel site, mediates electron flow from CO to the Fe-S centers of CO dehydrogenase.

8527 **Nickel-specific, slow-binding inhibition of carbon monoxide dehydrogenase from Rhodospirillum rubrum by cyanide.** Ensign, S.A. (Univ. of Wisconsin, Madison (USA)); Hyman, M.R.; Ludden, P.W. *Biochemistry (USA)*, 28(12): 4973-4979 (13 Jun 1989). DOE Contract FG02-87ER13691.

The inhibition of purified carbon monoxide dehydrogenase from Rhodospirillum rubrum by cyanide was investigated in both the presence and absence of CO and electron acceptor. The inhibition was a time-dependent process exhibiting pseudo-first-order kinetics under both sets of conditions. The true second-order rate constants for inhibition were 72.2 M^{-1} s^{-1} with both substrates present and 48.9 and 79.5 M^{-1} s^{-1}, respectively, for the reduced and oxidized enzymes incubated with cyanide. CO partially protected the enzyme against inhibition after 25-min incubation with 100 μM KCN. Dissociation constants of 8.46 μM (KCN) and 4.70 μM (CO) were calculated for the binding of cyanide and CO to the enzyme. Cyanide inhibition was fully reversible under an atmosphere of CO after removal of unbound cyanide. N_2 was unable to reverse the inhibition. The competence of nickel-deficient (apo) CO dehydrogenase to undergo activation by $NiCl_2$ was unaffected by prior incubation with cyanide. Cyanide inhibition of holo-CO dehydrogenase was not reversed by addition of $NiCl_2$. $^{14}CN^-$ remained associated with holoenzyme but not with apoenzyme through gel filtration chromatography. These findings suggest that cyanide is a slow-binding, active-site-directed, nickel-specific, reversible inhibitor of CO dehydrogenase. The authors propose that cyanide inhibits CO dehydrogenase by being a analogue of CO and by binding through enzyme-bound nickel.

8528 **Imaging of single uncoated DNA molecules by scanning tunneling microscopy.** Keller, D. (Univ. of New Mexico, Albuquerque (USA)); Bustamante, C.; Keller, R.W. *Proceedings of the National Academy of Sciences of the United States of America (USA)*, 86(14): 5356-5360 (Jul 1989).

Scanning tunneling microscope images of DNA molecules adsorbed onto highly oriented pyrolytic graphite have been obtained. Three methods of deposition and sample preparation have been utilized. In the first method, a highly concentrated solution of DNA is sonicated, and a drop is deposited on freshly cleaved graphite. Under these conditions, the molecules tend to align in a parallel fashion, forming liquid-crystalline phases. In the second method, a solution of DNA is deposited directly on the graphite surface without sonication. In this case, ammonium acetate, a volatile salt, is used to decrease the amount of the residual salt crystals left after drying. In the third method, a solution containing lysed phage particles and DNA is adsorbed onto a graphite surface. The molecules are seen either isolated or in small bundles. The values of height, periodicity, and thickness observed and the handedness of the molecules are consistent with those expected for DNA. In all cases, the molecules were identified by their characteristic periodic structure and because, at higher magnification, no graphite-like structure was detectable on the surface of the molecules. Often the DNA molecules appear to adsorb in areas of the graphite that have many steps and defects. A mechanism that explains the magnitude of the tunneling currents measured in DNA is proposed. This mechanism, in turn, suggests a general method by which large insulating molecules can be rendered conductive.

8529 **Is there an excitonic interaction or antenna system in bacteriorhodopsin?.** El-Sayed, M.A. (Univ. of California, Los Angeles (USA)); Lin, C.T.; Mason, W.R. *Proceedings of the National Academy of Sciences of the United States of America (USA)*, 86(14): 5376-5379 (Jul 1989). DOE Contract FG03-88ER13828.

The presence of a biphasic circular dichroism (CD) observed in the visible absorption spectrum of retinal in bacteriorhodopsin (bR) has been believed for many years to be due to excitonic-type interaction within the trimeric structure of the retinal in the protein membrane. In the present work, the authors present data and discuss previous observations that strongly suggest the absence of such an excitonic interaction. The magnetic CD spectrum of the trimer is found to be similar to that of the monomer and shows no sign of absorption to the double degenerate state predicted to be present from the exciton theory. This, together with the previous observations on the CD spectra of the photocycle intermediates of bR as well as the linear polarization studies of the fluorescence and the daughter absorption, sheds doubt on the presence of exciton interaction and thus suggests the presence of neither an antenna system nor a viable special reaction center in bR. Possible explanation for the observed biphasic nature of the CD spectrum is given in terms of having more than one type of bR with different protein conformations around the retinals in the trimer giving each similar absorption maximum but opposite signs for its rotary dispersion power.

8530 **Carbonyl sulfide inhibition of CO dehydrogenase from Rhodospirillum rubrum.** Hyman, M.R. (Univ. of California, Riverside (USA)); Ensign, S.A.; Arp, D.J.; Ludden, P.W. *Biochemistry (USA)*, 28(17): 6821-6826 (22 Aug 1989).

Carbonyl sulfide (COS) has been investigated as a rapid-equilibrium inhibitor of CO oxidation by the CO dehydrogenase purified from Rhodospirillum rubrum. The kinetic evidence suggests that the inhibition by COS is largely competitive versus CO (K_i = 2.3 μM) and uncompetitive versus methylviologen as electron acceptor. The data are compatible with a ping-pong mechanism for CO oxidation and COS inhibition. Unlike the substrate CO, COS does not reduce the iron-sulfur centers of dye-oxidized CO dehydrogenase and thus is not an alternative substrate for the enzyme. However, like CO, COS is capable of protecting CO dehydrogenase from slow-binding inhibition by cyanide. A true binding constant (K_D) of 2.2 μM for COS has been derived on the basis of the saturable nature of COS protection against cyanide inhibition. The ability of CO, CO_2, COS, and related CO/CO_2 analogues to reverse cyanide inhibition of CO dehydrogenase is also demonstrated. The kinetic results are interpreted in terms of two binding sites for CO on CO dehydrogenase from R. rubrum.

8531 **Electron transfer between cytochrome α and copper A in cytochrome c oxidase: A perturbed equilibrium study.** Morgan, J.E. (California Institute of Technology, Pasadena (USA)); Li, P.M.; Jang, D.J.; El-Sayed, M.A.; Chan, S.I. *Biochemistry (USA)*, 28(17): 6975-6983 (22 Aug 1989).

Intramolecular electron transfer in partially reduced cytochrome c oxidase has been studied by the perturbed equilibrium method. The authors have prepared a three-electron-reduced, CO-inhibited form of the enzyme in which cytochrome a and copper A are partially reduced and in an intramolecular redox equilibrium. When these samples were irradiated with a nitrogen laser to photodissociate the bound CO, changes in absorbance at 598 and 830 nm were observed which were consistent with a fast electron transfer from cytochrome a to copper A. The absorbance changes at 598 nm gave an apparent rate of 17,000 $\pm$ 2,000 s^{-1} (1 σ), at pH 7.0 and 25.5°C. These changes were not observed in either the CO mixed-valence or the CO-inhibited fully reduced forms of the enzyme. The rate was fastest at about pH 8.0, falling off toward both lower and higher pHs. There was a small but clear temperature dependence. The process was also observed in the cytochrome c-cytochrome c oxidase high-affinity complex. The electron equilibration measured between cytochrome α and copper A is far faster than any rate measured or inferred previously for this process.

5503 Cytology

8532 (CONF-8911146–1) **Molecular targets, DNA breakage, DNA repair: Their roles in mutation induction in mammalian germ cells.** Sega, G.A. Oak Ridge National Lab., TN (USA). [1989]. 21p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. From Banbury Center conference on mutation

induction and heritability in mammalian germ cells; Cold Spring Harbor, NY (USA); 12-15 Nov 1989. Order Number DE90003715. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Variability in genetic sensitivity among different germ-cell stages in the mammal to various mutagens could be the result of how much chemical reaches the different stages, what molecular targets may be affected in the different stages and whether or not repair of lesions occurs. Several chemicals have been found to bind very strongly to protamine in late-spermatid and early-spermatozoa stages in the mouse. The chemicals also produce their greatest genetic damage in these same germ-cell stages. While chemical binding to DNA has not been correlated with the level of induced genetic damage, DNA breakage in the sensitive stages has been shown to increase. This DNA breakage is believed to indirectly result from chemical binding to sulfhydryl groups in protamine which prevents normal chromatin condensation within the sperm nucleus. 22 refs., 5 figs.

5504 Genetics

Refer also to citation(s) 8485

8533 (EPRI-GS–6591) **The application of molecular genetics techniques to bioremediation processes: Final report.** Alpert, S. (Alpert (S.), Palo Alto, CA (USA)). Electric Power Research Inst., Palo Alto, CA (USA); Alpert (S.), Palo Alto, CA (USA). c Dec 1989. 104p. Sponsored by Electric Power Research Institute. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

Bioremediation is a process in which microorganisms are used to degrade toxic compounds. This technology has been used successfully to clean up a number of organic wastes including diesel fuel and creosote. Due to the increasingly stringent regulations affecting contaminated sites, a number of new technologies are being pursued that attempt to remediate wastes in situ, thus leaving the wastes undisturbed. One such pursuit has led to the proposal that molecular genetic techniques can be used to assess the genetic ecology of a contaminated waste site and that, subsequently, one can manipulate the indigenous microbial population so as to increase the biodegradation rate. Such a technology is heavily dependent on molecular genetic technique such as gene probing to determine the presence, distribution and ability of microbial genes to be expressed/amplified in the contaminated soil or water matrix. 117 refs., 14 figs., 13 tabs.

8534 **Mutation and selection in bacterial populations: Alternatives to the hypothesis of directed mutation.** Lenski, R.E. (Univ. of California, Irvine (USA)); Slatkin, M.; Ayala, F.J. *Proceedings of the National Academy of Sciences of the United States of America (USA)*, 86(8): 2775-2778 (Apr 1989).

Bacterial populations have served as model systems for studying evolutionary processes ever since the classic experiments of Luria and Delbrueck, which demonstrated the occurrence of mutations prior to selection for the traits they conferred. However, several authors have recently presented experiments suggesting that bacteria may have mechanisms for directing which mutations occur, such that the rate of adaptive mutations is enhanced. Before the hypothesis of directed mutation is accepted, it is imperative to consider alternative hypotheses that might account for the same observations. To this end, the authors expand upon existing mathematical theory of the dynamics of mutation and selection in clonal populations for two cases of particular interest. The first case concerns selection against mutants before plating; this selection occurs as the result of differences in growth rate between mutants and nonmutants. The second case concerns the sequential incorporation of two mutations as the result of selection for an intermediate genotype after plating. These two cases therefore provide alternatives to the hypothesis of directed mutation. They suggest experiments that might be used to examine our alternative hypotheses. They also contrast the hypothesis of directed mutation with the notion of inheritance of acquired characteristics.

5505 Metabolism

Refer also to citation(s) 7152, 7156, 7157, 7158, 7159, 7162, 7163, 7164, 7172, 7174, 7175, 8541, 8542

5506 Medicine

8535 (INIS-mf–12040) **A prognostic index for the thyroid carcinoma as derived from patients treated in the Department of Nuclear Medicine at Wuerzburg University.** Reimann, J. Wuerzburg Univ. (Germany, F.R.). Medizinische Fakultaet. 20 Jul 1987. 139p. (In German). Order Number DE90732614. Available from NTIS (US Sales Only), PC A07/MF A01.

A group of patients showing uniform histological and therapeutic characteristics was subjected to statistical analysis using a method adapted from a similar multicentre study. The following risk factors were evaluated on the basis of a multidimensional arithmetic procedure (Weibull's function): Age, sex, histological classification, presence of anaplastic cells, size of tumour, metastisation distant from the primary tumour. Its predictive value for survival time was compared with the results from other analyses. In the further course of the study additional parameters were investigated at the diagnostic and therapeutic levels. It is of particular note that a large number of tumours were diagnosted at an early stage. (TRV).

8536 (INIS-mf–12041) **Aspects pertinent to the usefulness of a solid phase radio-immuno-sorbent assay for the detection of spermatozoa antibodies in sera of infertility patients.** Hinrichs-Reiche, I. Kiel Univ. (Germany, F.R.). Medizinische Fakultaet. 29 Sep 1987. 47p. (In German). Order Number DE90732610. Available from NTIS (US Sales Only), PC A03/MF A01.

The solid phase Radio-Immuno-Sorbent Assay (RISA) is a highly sensitive and valid test to detect 125-iodinetagged antibodies to spermatozoa that allows qualitative and quantitative evaluations of sperm-incapacitating immunglobulin Ig G in sera from patients believed to be infertile for immunological reasons. The study failed to reveal any correlations between the results of RISA and those of micro-sperm-agglutination or micro-sperm-immobilisation tests. There was a major body of evidence pointing to possible links between female isoimmunity and male autoimmunity. (TRV).

8537 (INIS-mf–12042) **Thyroid scintigraphy using coded apertures derived from a complex Fresnel zone plate.** Meinke, J. Tuebingen Univ. (Germany, F.R.). Medizinische Fakultaet. 1986. 48p. (In German). Order Number DE90732609. Available from NTIS (US Sales Only), PC A03/MF A01.

Comparative evaluations of conventional scintiscanning and Fresnel zone plate imaging carried out in the thyroid for the purposes of this study showed that the purported benefits of the latter technique were confirmed by phantoms but did to a lesser extent bear out in patients. Major drawbacks are the lack of additional information of clinical relevance, the greater length of time needed and the difficult interpretation of artefacts. (TRV).

8538 (INIS-mf–12045) **Relationship between cerebral angiography, Doppler ultrasound velocimetry in the major cervical vessels and cerebral blood flow as determined by cerebrography using xenon.** Seebach, H.M. Wuerzburg Univ. (Germany, F.R.). Medizinische Fakultaet. 29 Jul 1987. 134p. (In German). Order Number DE90732602. Available from NTIS (US Sales Only), PC A07/MF A01.

Retrospective analysis of patient data gave evidence to prove that the findings revealed in the major cervical vessels by means of the Doppler ultrasound technique and angiography were largely consistent (in 82-90.8% of cases); the Doppler flow values recorded for advanced stenoses, by contrast with those obtained in stenoses of a minor degree were always characterised by a distinctive pattern; unless the patient examined showed acute ischemia, stenoses of the two carotid arteries or the vertebral artery had no perceptible influence on the rCBF values; the most valuable information as to the quality of cerebral blood flow was provided by the parameters of the Doppler ultrasound technique; reduced rCBF and Doppler flow values confirmed the preliminary diagnosis in cases of suspected generalised arteriosclerosis. (TRV).

8539 (INIS-mf–12046) **Development of a technique for three-dimensional image reconstruction from emission computed tomograms (ECT).** Gerischer, R. Wuerzburg Univ. (Germany, F.R.). Medizinische Fakultaet. 20 Jul 1987. 66p. (In German). Order Number DE90732601. Available from NTIS (US Sales Only), PC A04/MF A01.

The described technique for three-dimensional image reconstruction from ECT sections is based on a simple procedure, which can be carried out with the aid of any standard-type computer used in nuclear medicine and requires no sophisticated arithmetic approach. (TRV).

8540 (INP–1331/B) **Present state and prospects of fast neutrons application in cancer therapy in Krakow.** Skolyszewski, J. (Centrum Onkologii im. M.Sklodowskiej-Curie, Krakow (Poland)); Huczkowski, J. Institute of Nuclear Physics, Cracow (Poland). 1986. 32p. (CONF-8604415–: Meeting of the Radiotherapy Commission of Medical Physics Committee of Polish Academy of Sciences, Cracow (Poland), 29 Apr 1986). Order Number DE90610924. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The results of the therapy in the group of 89 patients with advanced head and neck cancer treated with fast neutrons (5.6MeV mean neutron energy) are presented. Fifteen patients (16.9%) survived two years and fourteen from them (15.7%) without any symptons of cancer. The pilot results of radiobiological experiments performed on clinical neutron beam are also included. These are: RBE determination with the use of Withers-Elkind microcolony assay (acute radiation effects on the survival of crypt cells in the mouse intestine) and the RBE determination for late large bowel stenosis in Wistar rats after local irradiation (Trott-Kiszel assay). Both assays will be used to study the RBE neutron beams from new isochronic cyclotron (accelerating deuterons up to 25 MeV and protons up to 50 MeV). Such cyclotron was built in Cracow and will be used also in neutron cancer therapy. 26 refs., 7 figs. (author).

8541 (LUMEDW-MEFL–1006-5-179-1989) **Ventilation and ventilation/perfusion ratios: Measurements of regional lung function based on positron emission tomography.** Valind, S.O. Lund Univ. (Sweden). Dept. of Clinical Physiology. 10 Mar 1989. 179p. Order Number DE90610919. Available from NTIS (US Sales Only), PC A09/MF A01 - OSTI; INIS.

The thesis is based on five different papers. The labelling of specific tracer compounds with positron emitting radionuclides enables a range of structural, physiological and biochemical parameters in the lung to be measured non-invasively, using positron emission tomography. This concept affords a unique opportunity for in vivo studies of different expressions of pulmonary pathophysiology at the regional level. The present thesis describes the application of positron emission tomography to the measurements of ventilation and ventilation/perfusion ratios using inert gas tracers, neon-19 and nitrogen-13 respectively. The validity of the methods applied was investigated with respect to the transport of inert gas tracers in the human lung. Both ventilation and the ventilation/perfusion ratio may be obtained with errors less than 10% in the normal lung. In disease, however, errors may increase in those instances where the regional ventilation is very low or the intra-regional gas flow distribution is markedly nonuniform. A 2-3 fold increase in ventilation was demonstrated in normal nonsmoking subjects going from ventral to dorsal regions in the supine posture. These large regional differences could be well explained by the intrinsic elastic properties of lung tissue, considering the gravitational gradient in transpulmonary pressure. In asymptomatic smokers substantial regional ventilatroy abnormalities were found while the regional gas volume was similar in smokers and nonsmokers. The uncoupling between ventilation and gas volume probably reflects inflammatory changes in the airways. The regional differences in dV/dt and dQ/dt were relatively small and blood flow was largely matched to ventilation in the supine posture. However, small regions of lung with very low ventilation, unmatched by blood flow commonly exists in the most dependent parts of the lung in both smokers and nonsmokers. (29 figs, 7 tabs, 113 refs).

8542 (ORNL/TM–11304) **Nuclear Medicine Program progress report for quarter ending June 30, 1989.** Knapp, F.F. Jr.; Ambrose, K.R.; Callahan, A.P.; Allred, J.F.; Blystone, S.L.; Hasan, A.; Lambert, C.R.; McPherson, D.W.; Srivastava, P.C.; Lambert, S.J.; Lisic, E.C.; Rice, D.E. Oak Ridge National Lab., TN (USA). Oct 1989. 15p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004395. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

In this report the development of a simple and inexpensive spectrophotometric technique to determine the specific activity of spallation-produced copper-67 (Cu-67) is described. The method is based upon the well-known strong absorption at 480 nm of the orange-colored copper (II) complexes with bis-thiosemicarbazone (TSC) ligands. We have used the Cu(II) complex of phenylglyoxal (PC-TSC) and determined a calibration curve in an acidic ethanol-acetate buffer which is linear up to a concentration of 40 ppM (40 μgm/ml) with a lower limit of detection of about 0.4 ppM. Also in this report, the results it the synthesis and tissue distribution in fasted rats of a series of five analogues of 3.3-dimethyl-substituted terminal para-iodophenyl fatty acids to determine the effects of total chain length on myocardial uptake and retention properties are summarized. The C-11, C-12, C-13, C-14, C-15 (3,3-DMIPP) and C-19 analogues were evaluated. The C-15 analogue showed the highest heart uptake. The shorter C-11 → C-14 and the C-19 chain lengths showed much lower heart uptake and heart:blood values. These studies clearly demonstrate that the position of dimethyl-branching and the total chain length are both important factors which affect myocardial uptake.

8543 (ORNL/TM–11377) **Nuclear Medicine Program progress report for quarter ending September 30, 1989.** Knapp, F.F. Jr.; Ambrose, K.R.; Callahan, A.P.; Allred, J.F.; Blystone, S.L.; Hasan, A.; McPherson, D.W.; Srivastava, P.C.; Lambert, C.R.; Lambert, S.J.; Rice, D.E. Oak Ridge National Lab., TN (USA). Dec 1989. 15p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004434. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

In this report, an evaluation of the effects of albumin and albumin plus sodium palmitate in the phosphate buffer perfusate on the relative of unmetabolized fatty acid and the unknown metabolite(s) from isolated rat hearts administered 15-(p-[I-125]iodophenyl)-3-(R, S)-methylpentadecanoic acid (BMIPP) is described. Earlier studies had demonstrated the presence of a major unidentified polar radioactive component in the outflow of hearts injected with BMIPP and perfused with the traditional Krebs-Henseleit (KH) buffer, which does not contain albumin. The current studies were performed with KH buffer containing either albumin (BSA) or albumin and palmitate (BSA/PAL) to assess the relative loss of the metabolite and unmetabolized BMIPP from the perfused hearts. The results demonstrated that in the presence of albumin both the unidentified material and BMIPP are present in the outflow (i.e., 5 min perfusate buffer, % BMIPP: KH, 3%; KH + BSA, 10%; KH + BSA/PAL, 41%). These results demonstrate that BMIPP is a major radioactive component in the outflow of isolated hearts using a perfusate containing BSA and palmitate and, more importantly, suggest for the first time that the slow myocardial wash-out observed in humans after administration of [I-123]BMIPP probably represents loss of both unmetabolized BMIPP and the unidentified metabolite. Coronary sinus sampling studies with dogs are now in progress to relate the relative contribution of these two components to the release of radioactivity from the heart. Also in this report, our population experience for several radioisotopes being used by the ORNL Nuclear Medicine Program is summarized.

8544 Crystal structure of core streptavidin determined from multi-wavelength anomalous diffraction of synchrotron radiation. Hendrickson, W.A. (Columbia, Univ., New York, NY (USA)); Paehler, A.; Smith, J.L.; Satow, Y.; Merritt, E.A.; Phizackerley, R.P. *Proceedings of the National Academy of Sciences of the United States of America (USA)*, 86(7): 2190-2194 (Apr 1989).

A three-dimensional crystal structure of the biotin-binding core of streptavidin has been determined at 3.1-Å resolution. The structure was analyzed from diffraction data measured at three wavelengths from a single crystal of the selenobiotinyl complex with streptavidin. Streptavidin is a tetramer with subunits arrayed in D_2 symmetry. Each protomer is an 8-stranded β-barrel with simple up-down topology. Biotin molecules are bound at one end of each barrel. This study demonstrates the effectiveness of multi-wavelength anomalous

diffraction (MAD) procedures for macromolecular crystallography and provides a basis for detailed study of biotin-avidin interactions.

8545 **Correlation of paramagnetic states and molecular structure in bacterial photosynthetic reaction centers: The symmetry of the primary electron donor in Rhodopseudomonas viridis and Rhodobacter sphaeroides R-26.** Norris, J.R. (Argonne National Laboratory, IL (USA)); Budil, D.E.; Gast, P.; Chang, C.H.; El-Kabbani, O.; Schiffer, M. *Proceedings of the National Academy of Sciences of the United States of America (USA),* 86(12): 4335-4339 (Jun 1989). DOE Contract W-31-109-ENG-38.

The orientation of the principal axes of the primary electron donor triplet state measured in single crystals of photosynthetic reaction centers is compared to the x-ray structures of the bacteria Rhodobacter (Rb.) sphaeroides R-26 and Rhodopseudomonas (Rps.) viridis. The primary donor of Rps. viridis is significantly different from that of Rb. sphaeroides. The measured directions of the axes indicate that triplet excitation is almost completely localized on the L-subunit half of the dimer in Rps. viridis but is more symmetrically distributed on the dimeric donor in Rb. sphaeroides R-26. The large reduction of the zero field splitting parameters relative to monomeric bacteriochlorophyll triplet in vitro suggests significant participation of asymmetrical charge transfer electronic configurations in the special pair triplet state of both organisms.

8546 **Structure of the active site of sulfite oxidase. X-ray absorption spectroscopy of the Mo(IV), Mo(V), and Mo(VI) oxidation states.** George, G.N. (Exxon Research and Engineering Company, Annandale, NJ (USA)); Kipke, C.A.; Prince, R.C.; Sunde, R.A.; Enemark, J.H.; Cramer, S.P. *Biochemistry (USA),* 28(12): 5075-5080 (13 Jun 1989).

The active site of sulfite oxidase has been investigated by X-ray absorption spectroscopy at the molybdenum K-edge at 4 K. The authors have investigated all three accessible molybdenum oxidation states, Mo(IV), Mo(V), and Mo(VI), allowing comparison with the Mo(V) electron paramagnetic resonance data for the first time. Quantitative analysis of the extended X-ray absorption fine structure indicates that the Mo(VI) oxidation state possesses two terminal oxo (Mo=O) and approximately three thiolate-like (Mo—S-) ligands and is unaffected by changes in pH and chloride concentration. The Mo(IV) and Mo(V) oxidation states, however, each have a single oxo ligand plus one Mo—O- (or Mo-N<) bond, most probably Mo—OH, and two to three thiolate-like ligands. Both reduced forms appear to gain a single chloride ligand under conditions of low pH and high chloride concentration.

8547 **Persistence of the α-helix stop signal in the S-peptide in trifluoroethanol solutions.** Nelson, J.W. (Louisiana State Univ., Baton Rouge (USA)); Kallenbach, N.R. *Biochemistry (USA),* 28(12): 5256-5261 (13 Jun 1989).

Alpha-helix formation in the S-peptide (residues 1-19 of ribonuclease A) was studied in detail by use of two-dimensional ^1H nuclear magnetic resonance to monitor the effects of 2,2,2-trifluoroethanol (TFE) at 0°C and pH 2.07. TFE stabilizes the S-peptide α-helix. Helix formation by a particular amino acid was monitored by the chemical shifts of the C^{α}, C^{β}, and C^{γ} protons while increasing the concentration of TFE: large changes in chemical shift of a particular residue indicate that it is induced to go helical, whereas small chemical shift changes indicate little helix formation. Residues Thr-3 to Met-13 undergo chemical shift changes consistent with helix formation, whereas the other residues do not. Earlier work reported that residues Thr-3 to His-12 become helical in aqueous solution. The existence of a helix stop signal was inferred from this behavior. The authors conclude that this helix stop signal persists in TFE solutions.

8548 **Changes in the structure of calmodulin induced by a peptide based on the calmodulin-binding domain of myosin light chain kinase.** Heidorn, D.B. (Los Alamos National Laboratory, NM (USA)); Seeger, P.A.; Rokop, S.E.; Blumenthal, D.K.; Means, A.R.; Crespi, H.; Trewhella, J. *Biochemistry (USA),* 28(16): 6757-6764 (8 Aug 1989).

Small-angle X-ray and neutron scattering data were used to study the solution structure of calmodulin complexed with a synthetic peptide corresponding to residues 577-603 of rabbit skeletal muscle myosin light chain kinase. The X-ray data indicate that, in the presence of Ca^{2+}, the calmodulin-peptide complex has a structure that is considerably more compact than uncomplexed calmodulin. The radius of gyration, R_g, for the complex is approximately 20% smaller than that of uncomplexed Ca^{2+}-calmodulin, and the maximum dimension, d_{max}, for the complex is also about 20% smaller. The peptide-induced conformational rearrangement of calmodulin is $[Ca^{2+}]$ dependent. The length distribution function for the complex is more symmetric than that for uncomplexed Ca^{2+}-calmodulin, indicating that more of the mass is distributed toward the center of mass for the complex, compared with the dumbbell-shaped Ca^{2+}-calmodulin. The solvent contrast dependence of R_g for neutron scattering indicates that the peptide is located more toward the center of the complex, while the calmodulin is located more peripherally, and that the centers of mass of the calmodulin and the peptide are not coincident. The scattering data support the hypothesis that the interconnecting helix region observed in the crystal structure for calmodulin is quite flexible in solution, allowing the two lobes of calmodulin to form close contacts on binding the peptide. This flexibility of the central helix may play a critical role in activating target enzymes such as myosin light chain kinase.

5507 Microbiology

Refer also to citation(s) 7102, 8532

8549 (ORNL–6558) **Vaccine refrigeration technologies and power sources.** Rovero, C. (Oak Ridge Associated Universities, Inc., TN (USA)); Waddle, D. Oak Ridge National Lab., TN (USA). Oct 1989. 29p. Sponsored by U.S. Agency for International Development. DOE Contract AC05-84OR21400. Order Number DE90004406. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Adequate refrigeration of vaccines is an essential component of the worldwide child immunization effort sponsored cooperatively by such development assistance agencies as the World Health Organization, the United Nations Children's Fund, and the US Agency for International Development (AID), and by developing countries. Unfortunately, the areas in most urgent need of effective immunization programs are often far from reliable refrigerated storage facilities or energy services. Selection of an appropriate energy supply and/or refrigeration technology has been seen as a limiting factor in effective immunization programs. In response to this problem, this document has been prepared to assist in the selection of reliable and affordable refrigeration systems. It provides information on refrigeration technologies and energy sources currently employed in the vaccine cold chain and discusses possible responses to a variety of energy-related problems, including intermittent or unreliable electric service, and unreliable supply, unavailability, or poor quality of fuels for refrigerators in health centers not served by the electric power grid. 18 refs., 5 figs.

8550 **Estimating Michaelis-Menten or Langmuir isotherm constants by weighted nonlinear least squares.** Persoff, P. (Lawrence Berkeley Lab., CA (USA)); Thomas, J.F. *Soil Science Society of America Journal (USA),* 52(3): 886-889 (May-Jun 1988). (CONF-881108–: 52. annual meeting of the Soil Science Society, Anaheim, CA (USA), 27 Nov - 2 dec 1988).

The authors derive a nonlinear least squares fitting method for determining either Michealis-Menten equation of Langmuir adsorption isotherm constants from experimental data for microbial growth rate. Data points can be weighted unequally if their relative precisions are known. Comparison of this method with the commonly used linearization methods, using simulated data sets containing normally distributed random errors, showed that this method yields more accurate and precise estimates of the constants than any of the linearizations. A short BASIC program to facilitate computation is presented.

5509 Pathology

Refer also to citation(s) 8513

8551 **Risk behavior-based model of the cubic growth of acquired immunodeficiency syndrome in the United States.** Colgate, S.A. (Los Alamos National Laboratory, NM (USA)); Stanley, E.A.; Hyman, J.M.; Layne, S.P.; Qualls, C. *Proceedings of the National Academy of Sciences of the United States of America (USA)*, 86(12): 4793-4797 (Jun 1989).

The cumulative number of cases of acquired immunodeficiency syndrome (AIDS) in the United States has grown as the cube of time rather than exponentially. The authors explain this by interactions involving partner choice and sexual frequency in a risk-behavior model with biased mixing. This leads to a saturation wave of infection moving from high- to low-risk groups. If this description is correct, then the decreasing growth rate of AIDS cases is not due to behavior changes; rather it is due to the intrinsic epidemiology of the disease.

5510 Physiological Systems

8552 (INIS-mf–11525) **Protection of spermatogenesis during X-irradiation and chemotherapy by temporary blood flow interruption.** van Vliet, J. Rijksuniversiteit Utrecht (Netherlands). 15 Jun 1989. 123p. Order Number DE90705971. Available from NTIS (US Sales Only), PC A06/MF A01 - OSTI.

In an animal model the possibility was tested to interrupt the blood flow to the testis temporarily and repeatedly. Subsequently, it was investigated whether blood flow interruption during irradiation or during cytostatic drug administration could limit the damage induced to the spermatogonial stem cells. The effect of repeated blood flow interruptions on spermatogenesis was evaluated. 192 refs., 15 figs., 11 tabs.

5530 Agriculture and Food Technology

Refer also to citation(s) 6752, 7055, 7098, 8429, 8430, 8557

8553 (CRIE-U–87042) **Study on supplemental lighting for vegetable cultivation.** Okabe, Katsumi. Central Research Inst. of Electric Power Industry, Abiko, Chiba (Japan). Nov 1988. 46p. (In Japanese). Order Number DE89910267. Available from NTIS (US Sales Only), PC A04/MF A01.

In order to make a lighting cultivation of vegetables practicable, the conditions of supplemental lighting on the growth of vegetables were investigated. The crops were cultivated and they were received artificial light 10 hours by two types of lamps (high-pressure sodium lamp and metal halide lamp) in the night. The growth of leaf lettuce, komatsuna and tomato seedling was promoted by supplemental lighting above 2.5 k lux, and the yield of these crops increased about 33 - 47 % to control (non lighting). Supplemental lighting in the latter stage of growth was more effective to growth compare with a lighting in the first half. When the quantity of solar radiation in the day time was controlled by shielding, the effect of supplemental lighting was heightened compare with a non-control case. The chlorophyll contents of leaves were increased by supplemental lighting. It is thought that the increased chlorophyll and supplemented light energy are primarily responsible for the increased photosynthesis. Electric consumption used supplemental lighting were about 0.8 kWh per plant in case of leaf lettuce and tomato seedling culture, and it was about 0.4 kWh per plant in case of Japanese honewort. Supplemental lighting by sodium lamp was suitable to growth of leaf lettuce and komatsuna, and metal halide lamp was suitable to growth of japanese honewort. This technic can be applied to vegetable cultivation in low daylight area in the standpoint of its effect and the economic condition. 8 refs., 15 figs., 26 tabs.

8554 (INS-R–340) **Irradiation of chilled lamb: A preliminary investigation.** Roberts, P.B;. Department of Scientific and Industrial Research, Lower Hutt (New Zealand). Inst. of Nuclear Sciences. Apr 1985. 24p. Order Number DE90612254. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

Chilled, vacuum-packed New Zealand lamb loins have been irradiated at doses between 1-8 kGy. The report outlines the methods used and provides dosimetry details. An appendix summarises the results of a taste trial conducted on the irradiated meat by the Meat Industry Research Institute of New Zealand. This showed that, even at 1 kGy, detectable flavours were induced by the radiation treatment. 4 refs; 6 figs; 6 tables.

56 BIOMEDICAL SCIENCES, APPLIED STUDIES

5601 Radiation Effects

Refer also to citation(s) 8113, 8349, 8539

8555 (BMU–1989-211) **Studies on the grain size distributions of radioactive dusts at the places of work and near sources emitting radioactive dust into the environment, and determination of the lung retention categories of radioactive chemicals on the basis of laboratory investigations.** Schriftenreihe Reaktorsicherheit und Strahlenschutz. Ergebnisberichte, Untersuchungen, Studien, Gutachten. Bundesministerium fuer Umwelt, Naturschutz und Reaktorsicherheit, Bonn (Germany, F.R.); Nuklear-Chemie und -Metallurgie G.m.b.H. (NUKEM), Hanau (Germany, F.R.). 1989. 116p. (In German). Contract BMU St.Sch. 994. Available from Available from GRM Werbeberatung - Werbemittlung - PR, Eggenstein-Leopoldshafen, (Germany, F.R.).

At working places of the RBU (pellet press, grinding machine) and the NUKEM (Nuclear Chemistry and Metallurgy Ltd.), (scrap processing, cermet line), the activity medium aerodynamic diameter (AMAD) was measured by means of cascade impactors and the alpha activity of radioactive aerosols (UO_2, UAl_x) was determined. The measured values were far below the acceptable emission values. In laboratory simulation tests for the determination of retention classes, the solubility of the dust particles in artificial lung fluids was analyzed, and the biological half-life values were measured as rate of dissolution. The sedimentation and retention model of the ICRP uses standardized values for the AMAD and the half-life values from which it is possible to deduce limiting values for the annual activity increase and the activity concentration of the room air. If the real material data is known, the maximum permissible values can be defined in accordance with working place requirements. (orig./HP).

8556 (BNL–43097) **Trace element distribution in the rat cerebellum.** Kwiatek, W.M.; Long, G.J.; Pounds, J.G.; Reuhl, K.R.; Hanson, A.L.; Jones, K.W. Brookhaven National Lab., Upton, NY (USA). [1989]. 7p. Sponsored by U.S. DOE Energy Research; U.S. Department of Health and Human Services. DOE Contract AC02-76CH00016. P41RR01838;ES04040. (CONF-8908165–2: 5. international conference on PIXE and its analytical applications, Amsterdam (Netherlands), 20-26 Aug 1989). Order Number DE90003965. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Spatial distributions and concentrations of trace elements (TE) in the brain are important because TE perform catalytic structural functions in enzymes which regulate brain function and development. We have investigated the distributions of TE in rat cerebellum. Structures were sectioned and analyzed by the Synchrotron Radiation Induced X-ray Emission (SRIXE) method using the NSLS X-26 white-light microprobe facility. Advantages important for TE analysis of biological specimens with x-ray microscopy include short time of measurement, high brightness and flux, good spatial resolution, multielemental detection, good sensitivity, and non-destructive irradiation. Trace elements were measured in thin rat brain sections of 20-micrometers thickness. The analyses were performed on sample volumes as small as 0.2 nl with Minimum Detectable Limits (MDL) of 50 ppb wet weight for Fe, 100 ppb wet weight for Cu, and Zn, and 1 ppM wet weight for Pb. The distribution of TE in the molecular cell layer, granule cell layer and fiber tract of rat cerebella was investigated. Both point analyses and two-dimensional semi-quantitative mapping of the TE distribution in a section were used.

8557 (ENEA-RT-PAS–89-14) **Evaluation of the dose committed as based on direct measurements with the Whole Body Counter: Chernobyl experience.** Meladani, C. (ENEA, Bologna (Italy)); Castellani, C.M.; Battisti, P.; Tarroni, G. ENEA, Rome (Italy). 1989. 41p. (In Italian). Order Number DE90610839. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

During normal working activities or in accidental situations, when the introduction of radioactive gamma emitters is non-negligible amount, accurate determination of effective committed dose equivalent based on direct measurements of the internal contamination cannot be avoided. Internal contamination measurements carried out by Whole Body Counter and the application of dosimetric and metabolic models as proposed by ICRP Publication 30 allow the intakes and committed dose equivalents to be evaluated. This paper presents the evaluation methodologies of committed dose equivalent both for istantaneous and extended contaminations. Furthermore, some advice about useful, opportune modes and time uncertainties due to the application of generalized models to particular situations, are also reported. On the basis of the Chernobyl experience, the general criteria for the chice and size of homogeneous groups of individuals to be measured, are finally submitted with a view to collecting the necessary radiation protection information concerning contamination of a part or a whole population.

8558 (HCR-CDTN–09) **Test of over-garments sterilization by gamma rays.** Bensiam, R. (Institut Pasteur d'Alger (Algerie)); Kahoul, A.S.; Meral, A.S.; Guemati, M.; Oularbi, S.; Boussaha, A.;. Haut Commissariat a la Recherche, Algiers (Algeria). Centre de Developpement des Techniques Nucleaires. Dec 1988. 8p. (In French). Order Number DE90612177. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS.

The aseptic state is absolutely necessary for a successful result of surgical operation. A single object badly cleaned and contaminated by microbes in the operating room may be the cause of the operation failure. The use of aseptic medical requisites is consequently essential to guarantee the security of the clinical practices. Besides, the asepsis prevents the nosocomial infections process that occurs in the hospitals and health centres.

8559 (INIS-mf–11562, pp. 20) **Monitoring of internal contamination with tritium of Jaslovske Bohunice nuclear power plant personnel.** Herchl, M. (Atomova Elektraren Bohunice, Jaslovske Bohunice (Czechoslovakia)); Ondris, D. Ceska Lekarska Spolecnost J.E. Purkyne, Prague (Czechoslovakia). Spolecnost Nuklearni Mediciny a Radiacni Hygieny; Institut Hygieny a Epidemiologie, Prague (Czechoslovakia). Ustav Hygieny Zareni; Ceskoslovenska Akademie Ved, Prague (Czechoslovakia). Ustav Dozimetrie Zareni; Vojenska Lekarska Akademie, Hradec Kralove (Czechoslovakia). Dec 1988. (In Slovak). (CONF-8812118–: 14. radiation hygiene days, Brno (Czechoslovakia), 8-9 Dec 1988). In *Abstracts of 14th radiation hygiene days.* Order Number DE90608347. Available from NTIS (US Sales Only), PC A05/MF A01 - OSTI; INIS.

Published in summary form only.

8560 (INIS-mf–12043) **Experimentally induced extrahepatic stenosis of the biliary tract - hepatobiliary dynamic scintigraphy and related procedures.** Metak, G. Technische Univ. Muenchen (Germany, F.R.). Fakultaet fuer Medizin. 11 Jun 1986. 117p. (In German). Order Number DE90732604. Available from NTIS (US Sales Only), PC A06/MF A01.

Biliary tract stenoses of varying degrees that have been artificially induced in rabbits are identified and quantified to a significant extent on the basis of hepatobiliary dynamic scintigraphy using 99mTc HIDA as well as of organisomorphic principles. Biochemical and physical parameters relevant to the function of the hepatobiliary tract are ascertained in long-term animal studies (pig model) both for physiological and experiment-induced pathological conditions. Moreover, the information provided by hepatobiliary dynamic scintigraphy is contrasted with that from parallel microsamples of bile. Comparisons between the results of contact cholangiography and hepatobiliary dynamic scintigraphy in pigs showing biliodigestive anastomoses fail to point to any links between the morphology and function of the extrahepatic biliary system. (TRV).

8561 (INIS-mf–12044) **Radioimmunoimaging of experimental gliomas using radiolabelled monoclonal antibodies.** Glaessner, H. Muenchen Univ. (Germany, F.R.). Tieraerztliche Fakultaet. 25 Jul 1986. 119p. (In German). Order Number DE90732603. Available from NTIS (US Sales Only), PC A06/MF A01.

The biodistribution and tumour uptake of radiolabelled (131 I) glioma-seeking monoclonal antibodies (14 AC1) and their $F(ab')_2$ fragments were investigated in nude mice having received glioma transplants. Radioimmunoimaging by external scintigraphy at 48 and 96 hours pointed to a superior tumour localisation by the fragments that was clearly related to the dose. Wholebody determinations of the biokinetic behaviour led to the following results: Faster clearance anc more ready elimination from the blood pool for the fragments, preferential uptake in the tumour; intact antibodies; binding in the liver, spleen and lungs. The study confirmed the value of fragments of monoclonal antibodies in the diagnosis of tumours and pointed to the possibility of using intact monoclonal antibodies as carriers of radioisotopes and cytotoxic drugs within the scope of therapeutic programmes. (TRV).

8562 (INS-R–358) **Radiological consequences in New Zealand of a northern-hemisphere dominated nuclear war.** Lassey, K.R.;. Department of Scientific and Industrial Research, Lower Hutt (New Zealand). Inst. of Nuclear Sciences. Jan 1987. 27p. Order Number DE90612179. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The doses delivered to the New Zealand population as a result of a postulated nuclear war are estimated. The postulated war is dominated by northern hemisphere exchanges with some detonations also over Australia; New Zealand is spared direct attack. The doses are estimated conservatively using models from the literature and are of similar order (a few mSv) from both the northern hemisphere conflict and Australian attacks. The impact of the latter supposes a near worst-case prevailing meteorology. The typical somatic effects of such doses are a few hundred cancer inductions protracted over half a century, and perhaps a significant incidence of thyroid disorders if no countermeasures prevent the production and consumption of contaminated milk. 25 refs; 6 tables.

8563 (Juel–2260) **Contribution of beta radiation to the radiation exposure in German nuclear power plants.** Heinzelmann, M. Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Abt. Sicherheit und Strahlenschutz. Jan 1989. 40p. (In German). Order Number DE90732331. Available from NTIS (US Sales Only), PC A03/MF A01.

The beta dose rate and shielding against beta radiation with protective clothing were measured at steam generators, RPV closure heads, condensation chambers, pipes, valves and turbines of seven German nuclear power plants. High proportions of beta radiation in the dose rate were only detected at relatively few points. There, however, the beta dose rates measured were partly very high; the ratio of the beta/gamma dose rate attained values of more than 40:1. The radiation fields differed considerably, both in their large and small-area dimensions, showing hard and soft beta radiation. This divergence in the radiation fields hardly permits any generally valid statements on the contribution of beta radiation to the body dose. Protective clothing can provide sufficient shielding against beta radiation in case of low-energy, soft beta radiation. In cases of activities in which hard beta radiation is particularly to be expected, e.g., in cases of work at steam generator entrances, the beta dose is measured with the official film dosemeter. The dosemeter has to be carried at the appropriate places. (orig./HP).

8564 (NIRS-R–16, pp. 6-10) **Serial sacrifice study on tumorigenesis in male C57BL/6J mice exposed to gamma-ray of fast neutron radiation.** Otsu, Horoshi (National Inst. of Radiological Sciences, Chiba (Japan)); Furuse, Takeshi; Noda, Yuko; Kobayashi, Shigeru; Maruyama, Takashi; Sato, Fumiaki. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

In this serial sacrifice study, we investigated the relationship between the incidence and time of the appearance of neoplasms in male specific pathogen-free C57BL/6J mice at 4 weeks of age, exposed to gamma-ray radiation from Cs-137 in graded doses of 1 to 5 Gy at a dose rate of 1 Gy/min or fast neutron radiation from a van de Graaff accelerator in doses of 1 to 3 Gy at a dose rate of 0.067 Gy/min. Radiation-induced lung tumor and liver tumor were more frequent than other types in most groups, and the incidence of both

kinds of tumors was found to be high enough to warrant an investigation of the dose responsiveness for tumorigenesis. These tumors began to appear 12 months after irradiation, and reached a maximum incidence in most groups 21 or 24 months after irradiation. In gamma-ray irradiated mice, lung tumor developed in a dose dependent manner, as did liver tumor, and in neutron irradiated mice, liver tumor grew 2.5 to 4.8 times more frequently than lung tumor, more siginificantly than in control mice, but any dose response relationship for lung tumor and liver tumor was obscure. In a comparison of the tumor incidence of the two different radiations, lung tumor incidence in 1 Gy neutron irradiated mice corresponded to the incidence in 5 Gy gamma-ray irradiated mice, and liver tumor incidence was 2 to 4 times higher in mice irradiated by neutrons than in those by gamma-rays at the same doses. Consequently, the relative biological effectiveness was calculated about 5. (author).

8565 (NIRS-R–16, pp. 11-22) **Influence of biological variables on radiation carcinogenesis.** Sasaki, Shunsaku (National Inst. of Radiological Sciences, Chiba (Japan)). National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

1. Age at exposure: Female $B6C3F_1$ mice were irradiated at day 17 of the prenatal age, or day 0, 7, 35, 105, 240 or 365 of the postnatal age with 1.9, 3.8 or 5.7 Gy of gamma-rays from ^{137}Cs. All mice were allowed to live through their entire lifespan under a specific pathogen free condition. It has become evident that mice of the late fetal period have susceptibility to induction of pituitary tumors, bone tumors, liver tumors, lung tumors, lymphocytic lymphomas and ovarian tumors. Neonatal mice were found to be more susceptible to induction of lymphocytic lymphomas, liver tumors and ovarian tumors than fetal mice. Irradiation of fetal or neonatal mice did not result in the excess development of myeloid leukemias and Harderian gland tumors, whereas these neoplasms were induced by irradiation at the adult period. 2. Combination effects of radiation and chemicals: Both sexes of $B6WF_1$ mice were exposed to X-rays at day 5 of postnatal age. After weaning, pellet diet containing 0.05 % phenobarbital was given until their natural death. It was rather surprising that life-shortening effect of X-irradiation was decreased by oral administration of phenobarbital. This effect seemed to be due to delayed development of neoplastic diseases. Administration of phenobarbital did not result in decrease in incidences of neoplasms. (author).

8566 (NIRS-R–16, pp. 65-72) **Protein factors regulating proliferation and differentiation of normal and neoplastic cells.** Shikita, Mikio (National Inst. of Radiological Sciences, Chiba (Japan)); Tsuneoka, Kazuko; Ishihara, Hiroshi. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

Human macrophage growth factor (M-CSF) and mouse granulocyte-macrophage growth factor (GM-CSF) were purified to homogeneity, and the amino acid composition and the N-terminal amino acid sequence of these protein factors were determined. With the use of these purified preparations, enhancing effect of the hematopoietic factors on the proliferation and functions of normal mouse myeloid cells and radiation-induced mouse leukemic cells were demonstrated. In addition, mouse fibrosarcoma cells were cloned and a line of cells secreting both M-CSF and neutrophil growth factor (G-CSF) were obtained. A number of subclones were isolated which displayed heterogeneity with regard to their ability of secreting the above-mentioned two types of CSFs, while equilibration of the cells was developed so that all subclones became similar after cultivation for some time. (author).

8567 (NIRS-R–16, pp. 23-31) **Studies on radiation-induced thymic lymphomagenesis in B10 strain mice.** Muto, Masahiro (National Inst. of Radiological Sciences, Chiba (Japan)); Kubo, Eiko; Kamisaku, Hitoko; Sado, Toshihiko. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

B10 Thy 1 congenic strain mice have been used in the systemic experiment on radiation-induced thymic lymphomagenesis. Among 91 thymectomized and irradiated B10. Thy 1.2 mice, which were grafted subcutaneously with neonatal thymuses from B10. Thy 1.1 donor mice, 37 developed lymphomas originating in the grafted thymuses. This suggested the indirect mechanism for development of radiogenic lymphomas. In an attempt to reveal viral involvement in the development of radiogenic lymphomas, rearrangement of various endogeneous murine leukemia virus (MuLV) genomes and leukemogenic potentiality of the bone marrow from fractionally irradiated mice were examined by injecting intrathymically into newborn mice. There was, however, no evidence supporting the involvement of endogenous MuLV or some kinds of transmissible agents during thymic lymphomagenesis. 'Preneoplastic' cells first appeared in the thymuses 4-8 days after irradiation, and might develop thymic lymphomas under the influence of thymic microenvironment. The 'thymus-dependent' preneoplastic cells were termed 'thymic prelymphoma cells'. These thymic prelymphoma cells were detected in 26.1% (6 of 23) of the test donor thymuses at 14 days, and in 63% or more (15 of 24 and 14 of 22) at 21 and 31 days after irradiation. Fractionated doses of X-irradiation induced drastic reduction of the number of pre T cells in the bone marrow and changed the thymus subpopulation pattern. Changes in expression of IL-2 receptor, various kinds of oncogenes, T cells receptor during lymphomagenesis may result in the development of cancer cells. This hypothesis must await further cellular or molecular biologic studies. (Namekawa, K).

8568 (NIRS-R–16, pp. 32-40) **Modifying factors of radiation induced myeloid leukemia of C3H/He mouse.** Yoshida, Kazuko (National Inst. of Radiological Sciences, Chiba (Japan)); Nishimura, Mayumi; Nemoto, Kumie; Seki, Masatoshi. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

The first experiment examined modifying factors, such as adrenocortical hormones, inflammatory reaction, and surgical stress, for radiation induced myeloid leukemia in C3H/He mice. The incidence of myeloid leukemia was not affected by a solitary subcutaneous injection of one mg of prednisolone acetate (predonine), but increased significantly by whole body irradiation, immediately followed by predonine. Augumentated effects of predonine was found in the 0.47 Gy, 1.42 Gy, and 2.84 Gy irradiated groups, but not found in the 4.73 Gy irradiated group. These results suggest that predonine itself did not have any effect on initiation of leukemogenesis, but promoted the incidence of radiation-induced myeloid leukemia. In the next experiment determining whether the incidence of myeloid leukemia was increased with stimulation of hematopoietic tissues, mice were inserted a piece of cellulose acetate membrane (CAM) into the peritoneal cavity. In the non-irradiated group of mice, CAM insertion did not affect the incidence of myeloid leukemia at all. The incidence of leukemia increased significantly by CAM insertion combined with irradiation of 2.84 Gy. Mice suffered from both surgical stress and inflammatory reaction after CAM insertion. Therefore, surgical stress was considered responsible for the development of radiation-induced leukemia. (Namekawa, K).

8569 (NIRS-R–16, pp. 41-47) **Cell kinetic studies on radiation induced leukemogenesis.** Nakao, Isamu (National Inst. of Radiological Sciences, Chiba (Japan)); Suzuki, Gen; Imai, Yasufumi; Kawase, Yoshiko; Nose, Masako; Hirashima, Kunitake; Bessho, Masami. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

The purpose of this study was threefold: (1) to determine the clonal origin of radiation-induced thymic lymphoma in mice with cellular mosaicism for phosphoglycerate kinase; (2) to determine the incidence and latent period of myeloid leukemia and thymic lymphoma induced by whole-body exposure to median doses (3.0 Gy

or less) in RFM/MsNrs-2 mice; and (3) to examine the influence of human recombinant interleukin-2 (hrIL-2). Thymic lymphoma was of a single cell origin. The incidence of radiation-induced myeloid leukemia and thymic lymphoma in RFM mice increased in a dose dependent fashion. Mean latent periods of both myeloid leukemia and thymic lymphoma after irradiation became shorter in proportion to radiation doses. When hrIL-2 was injected to RFM mice receiving 3.0 Gy, mean survivals were shorter in thymoma-bearing mice than the control mice. This suggested that hrIL-2 shortens the promotion step of thymoma. Administration of hrIL-2 failed to alter the incidence of myeloid leukemia or the mean survival of mice having myeloid leukemia, indicating that the protocol of hrIL-2 administration was not so sufficient as to alter the myeloid leukemogenesis. (Namekawa, K).

8570 (NIRS-R–16, pp. 48-56) **Cytogenetical studies on the mechanism of radiation induced neoplasms.** Hayata, Isamu (National Inst. of Radiological Sciences, Chiba (Japan)); Ichikawa, Yayoi; Minamihisamatsu, Masako; Ishihara, Takaaki. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

Previous experiment revealed that a consistent chromosomal aberration of the partially deleted No.2 (2q-) is involved in tumor genesis. Therefore, a series of cytogenetic studies have performed: (1) to identify the time when the appearance of 2q- is detected during the genesis of myeloid leukemia in the irradiated mice; (2) to test malignancy of bone marrow cells with 2q- that were found before the development of leukemic symptoms in the irradiated mice; (3) to determine cytogenesis in the hematopoietic tissues in mice irradiated by different conditions; (4) to analyze oncogenes mapped on No.2 chromosome in normal and leukemic mice; (5) to determine cytogenesis of a new myeloproliferative neoplasia, L-8313; and (6) to analyze karyotype in various tumors. The cells with 2q- were detected before the development of myeloid leukemia symptoms in the irradiated mice. The emergence of 2q- did not have the ability enough to cause malignancy. When mice received whole body irradiation of either a dose of 3 Gy in a single fraction (dose inducing myeloid leukemia) or a dose of 6.8 Gy in 4 fractions (dose inducing lymphoid leukemia), No.2 chromosome aberration was more frequently observed in the cells of the single fraction group with 3 Gy than those of the fractionated group with a total dose of 6.8 Gy. Rearrangement of the DNA segments coding oncogenes was not detected. In the host mice with the injection of L-8313, dominantly diving cells in the leukemic spleen were newly developed, leukemic host cells in which the keryotype of a malignant cell could not be prepared by the 'conventional' method of chromosome analysis. Various chromosomal rearrangements, specific or non-specific to tumors, were observed. Genesis of radiation-induced myeloid leukemia seems to have sequential stages as follows; the chromosomal rearrangement, preleukemia, malignant transformation, and leukemia stages. (Namekawa, K).

8571 (NIRS-R–16, pp. 57-64) **Molecular biological study on genetic stability of the genome.** Hori, Tada-aki (National Inst. of Radiological Sciences, Chiba (Japan)); Takahashi, Ei-ichi; Tsuji, Hideo; Tsuji, Satsuki. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

A population cytogenetic study has been performed in 1022 healthy subjects and 547 cancer patients to determine baseline frequencies of autosomal rate fragile sites. Out of 17 rare autosomal fragile sites defined in HBM9 (1985), the following six were detected: fra(2)(q11), fra(10)(q25), fra(11)(q13), fra(11)(q23), fra(16)(q22) and fra(17)(q12). Other three new fragile sites were also detected: fra(8)(q24.1), fra(11)(q15.1) and fra(16)(p12.1). They were all distamycin A-inducible and located at the junctions of G/R-bands. The incidence of these autosomal fragile sites was 5% in both healthy subjects and cancer patients. Distamycin A-induced fragile sites may play a role in the etiology of leukemia, myeloproliferative disorders, and gynecological tumors. The present study also examined the mechanism of fragile X expression associated with fragile X syndrome in thymidine-prototrophic and auxotrophic human-mouse somatic cell hybrids. In these hybrid cells, both low and high thymidylate stresses were found to be effective in inducing fragile X expression, even in a hybrid clone that retained a fragile X chromosome as the only human chromosome. An addition of deoxycytidine completely abolished the effect of high thymidylate stress achieved by excess amounts of thymidine. It is concluded that the expression is an intrinsic property of the fragile X mutation resulting from chromosomal change in a special class of replicons with polypurine/polypyrimidine DNA sequence. (Namekawa, K).

8572 (NIRS-R–16, pp. 76-83) **Studies on dose-response relationships for induction of chromosome aberrations in stem-spermatogonia of the crab-eating monkey after low and high dose-rate gamma-irradiation.** Tobari, Izuo (National Inst. of Radiological Sciences, Chiba (Japan)); Matsuda, Yoichi; Utsugi, Toyoko; Nakai, Sayaka. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

Radiation-induced reciprocal translocations in stem-spermatogonia were examined with the crab-eating monkey, Macaca fascicularis. Monkeys were subjected to acute gamma irradiation at the dose rate of 0.25 Gy. The frequency of the translocation was 0.09% (65/3,500 cells) in the 1 Gy group, 2.50% (74/3,000 cells) in the 2 Gy group, and 1.30% (40/3,000 cells) in the 3 Gy group. Linear dose-response relationship for translocation induction lied in the range of 0 to 1 Gy. The dose-response curve was well fitted with the linear equation indicated by $Y=1.08 \times 10^{-3} + 1.79 \times 10^{-2}$ D. In the range of 0 to 3 Gy, the dose-response curve was humped with a peak yield around 2 Gy. When the monkeys received chronic gamma irradiation (1.8×10^{-5} Gy/min, approximately 0.024 Gy/22 h/day), the frequency of translocation was 0.15% (11/7,500 cells) in the 0.3 Gy group, 0.27% (16/6,000 cells) in the 1.0 Gy group, and 0.33% (13/4,000 cells) in the 1.5 Gy group. The dose-response relationship for translocation was linear with a regression coefficient of 0.16×10^{-2} and was expressed as $Y=0.94 \times 10^{-3} + 0.16 \times 10^{-2}$ D. The frequency of translocation was approximately ten times higher in the group receiving high dose rate gamma iradiation than that receiving low dose rate irradiation (1.79/100 cells vs 0.16/100 cells). Dose-response relationship was noticeable in the case of crab-eating monkeys. (Namekawa, K).

8573 (NIRS-R–16, pp. 91-98) **Effects of ionizing radiation on male germ cells of crab-eating monkey.** Okamoto, Masanori (National Inst. of Radiological Sciences, Chiba (Japan)); Kitazuma, Masayuki; Tobari, Izuo. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

Effects of ionizing radiation on sperm concentration, testicular volume, and sperm shape of the crab-eating monkey were studied by using acute and low dose-rate gamma-ray and X-ray. The animals were acutely irradiated with 0.25-3.00 Gy with Cs-137 gamma-ray at a dose-rate of 0.25 Gy/min. Sperm concentrations were decreased with time after irradiation in a dose-dependent fashion. The time required for the lowest concentration of sperm depended on radiation doses. A linear dose-response relationship was seen for sperm concentrations. In comparing the present results in monkeys to previous results in mice and golden hamsters, the sensitivity of spermatogenic cells in killing effect of gamma ray varied in the following order: monkeys>hamsters>mice. The present monkeys were also subjected to whole-body irradiation with 0.3-1.5 Gy of Cs-137 gamma-ray at 1.8×10^{-5} Gy/min, for the purpose of estimating low-dose rate irradiation on sperm concentrations, testicular volume and sperm shape. Noticeable changes in either sperm concentration or testicular volume did not occur by irradiation of 0.3 Gy. Sperm concentrations were markedly changed with 1.0 Gy. Changes in sperm concentrations and testicular volume after X-ray irradiation at the dose-rate of 0.32 Gy/min showed that killing effects of X-ray are apparently higher than those of gamma-ray. When the incidence of abnormal head shapes of sperm was examined in monkeys with

chronic gamma-ray irradiation, the highest incidence of abnormality was 1.5-1.8% at 0.25-0.50 Gy. The incidence of sperm abnormality in monkeys was comparable to that in hamsters; however, it was markedly higher in mice than monkeys. (Namekawa, K).

8574 (NIRS-R–16, pp. 102-109) **Movement and metabolism of radioactive particles in the respiratory tract.** Takahashi, Sentaro (National Inst. of Radiological Sciences, Chiba (Japan)); Kubota, Yoshihisa; Matsuoka, Osamu. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

In order to obtain some fundamental knowledge about the movement of radioactive particles in the respiratory tract, the following three series of experiments were carried out. (1) The lymphatic drainage of particulate materials deposited in the respiratory tract was determined in Fisher 344 rat by using colloidal carbon, $^{133}BaSO_4$ and ^{198}Au-colloid as tracer materials. While the lung region may be drained mainly to the posterior mediastinal lymph nodes, the tracheal wall drains primarily to the internal jugular and posterior cervical nodes. (2) Long-term retention of intracheally administered $BaSO_4$ particles in the rat trachea was determined up to 6 months after injection. The amount of ^{133}Ba retained 1 week after injection in the caudal region of the trachea was 0.41 % of the initial dose. Thereafter the ^{133}Ba was cleared exponentially with a mean half-time of 88 days. (3) The deposition and clearance of inhaled or instilled ^{198}Au-colloid were studied in rats with pulmonary lesions induced by delayed type hypersensitivity (DTH) reactions. The initial deposition of inhaled ^{198}Au-particles was significantly decreased in the lung lobes with DTH lesions. Early mucociliary clearance of ^{198}Au-particles was also impaired in the lung with DTH. These results suggest that the deposition pattern and the subsequent movements of inhaled particles in the respiratory tract might be considerably influenced by pathologic conditions in the lung. (author).

8575 (NIRS-R–16, pp. 120-128) **Comparative toxicological studies on the effects of internal exposures: Pulmonary fibrosis by inhalation of toxic particles and its relations to pulmonary alveolar macrophages. .** Oghiso, Yoichi (National Inst. of Radiological Sciences, Chiba (Japan)); Fukuda, Satoshi; Iida, Haruzo; Yamada, Yuji; Kubota, Yoshihisa; Matsuoka, Osamu. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

In order to study the toxicological mechanism of transuranic elements, such as plutonium, involved in the induction of pulmonary fibrosis, toxic effects of several inhaled dusts and mineral particles were examined in rats. Pulmonary alveolar macrophage (PAM) was responsible for retention and behavior of inhaled asbestos fibers or silica particles and their transfer to the lymph nodes. PAM exhibited prominent phagocytosis of particles, followed by a significant release of lactic dehydrogenase and beta-glucuronidase. Multinucleated or la-positive PAM was frequently observed in rats presenting with pulmonary fibrosis. Pulmonary fibrosis that was induced by inhaled asbestos or silica particles was associated with significant production and release of cytokines. This indicated a close correlation with inflammatory or proliferating responses of fibroblasts and lymphocytes. Such reactions observed in PAM depended on toxicity of particles involved in phagocytosis (i.e., the ability of particles to induce pulmonary fibrosis), suggesting heterogeneity in the population of PAM. (Namekawa, K).

8576 (NIRS-R–16, pp. 129-135) **Comparative toxicological studies on the effects of internal exposures: Bone metabolism and toxicity of DTPA in experimental animals. .** Oghiso, Yoichi (National Inst. of Radiological Sciences, Chiba (Japan)); Fukuda, Satoshi; Iida, Haruzo; Yamada, Yuji; Kubota, Yoshihisa; Matsuoka, Osamu. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

Age-related changes in bone metabolism of normal beagle dogs, from 3 months to 17 years of age, were examined by morphometric and serum biochemical values. From 3 months to 2 years of age, bone volume (BV/TV) and trabecular thickness (Th. Tb.) in the iliac trabecular bone, labeled with tetracycline and calcein, increased rapidly with an increase of body weight. Mineral apposition rate (MAR) and bone formation rate (BFR, equivalent to bone turnover rate) decreased. The BFR at 3 months was approximately 11 times in males and 15 times in females higher than that at 2 years when bone metabolism was of adult type. From 2 to 10 years of age, BV/TV or Th. Tb. did not remarkably change, whereas both MAR and BFR had a tendency to decrease gradually with age. Parathyroid hormone level increased from 3 months to 17 years. Testosterone level increased up to 2 years and remained almost constant thereafter. Serum osteocalcin, alkaline phosphatase, and phosphorus decreased rapidly up to 2 years, although calcium did not change with age. Effects of swimming (exercise) and lactate calcium on osteoporotic bones in rats were examined. The BV/TV and Th. Tb. increased, but the MAR and BFR were improved to be sustained. These changes were promoted by the administration of calcium and vitamin D_3. Toxicological study on DTPA revealed the following results: (1) Both hypocalcemia, following an increase of blood pressure, and heart failure were observed by iv injection of Zn-DTPA, but not observed by iv injection of Ca-DTPA. When DTPA was given orally, Ca-DTPA was more toxic than Zn-DTPA. DTPA toxicity induced dysfunction of the kidney and liver, hemorrhage and congestion in the lamina propria, and vascular expansion of the small intestine. Vascular permeability was also enhanced by either Ca-DTPA or Zn-DTPA. DTPA toxicity was found to be manifested by disturbed cardiovascular system. (Namekawa, K).

8577 (NIRS-R–16, pp. 145-153) **Methodological studies on the inhalation of radioactive aerosols.** Yamada, Yuji (National Inst. of Radiological Sciences, Chiba (Japan)); Kubota, Yoshihisa; Fukuda, Satoshi; Oghiso, Yoichi; Iida, Haruzo; Matsuoka, Osamu. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

Studies on inhalation exposure to radioactive aerosols requires many factors including (1) aerosol generation and treatment to provide the desired aerosol particles, (2) exposure system to provide the uniformity of inhaled aerosol particles and to minimize the external contamination in animals, and (3) safety system of the exhaust filter and its operating and control system. Prior to designing inhalation exposure system, an attempt was made to examine a feasibility of using whole-body plethysmography as a respiratory measurement method during exposure. Its accuracy was confirmed by an exposure container. The present project has developed two inhalation exposure systems for small rodents and dogs. These systems are housed in a large glove-box with double-cover doors. The small exposure system makes 20 or less rodents to be simultaneously exposed to radioactive aerosols. Each animal is held in a specially designed container for exposure. The container also serves as whole-body plethysmography. The exposure system was tested by using Au-198 aerosol particles 1.2 mum in activity median aerodynamic diameter and 2.0 in geometric standard deviation. Ten Wister rats were exposed for 1 hour. The rats were sacrified immediately after exposure and external contaminatinon in each rat was measured. No activity was detected. At the same time, aerosol sampling was made during exposure at several positions in the glove-box. Statistically significant activity was not counted for all sampling filters. Test of aerosol generation and aerosol control system including emergency circuit was also made and satisfactory results were obtained. (Namekawa, K).

8578 (NIRS-R–16, pp. 154-162) **Removal of transuranic elements by DTPA.** Matsuoka, Osamu (National Inst. of Radiological Sciences, Chiba (Japan)); Sato, Hiroshi. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

In vitro study was made on effects of calcium diethylenetriaminepentaacetic acid (Ca-DTPA) and macrophage activating substances - lipopolysaccharide (LPS) and zymosan - on Fe-59 release from rabbit alveolar macrophage incorporating Fe-59 iron dextran. Alveolar macrophages were cultured in Hanks' balanced salt solution at 37deg C for 8 hrs with or without the agents. An addition of Ca-DTPA gave a four-fold increase in Fe-59 release. The effect of either LPS or zymosan on Fe-59 release was not so great as that of Ca-DTPA; however, the concomitant use of either substance and Ca-DTPA increased Fe-59 release. In vivo study was similarly made in rats of which lungs were instilled with Fe-59 iron dextran. After instillation, animals were treated with DTPA on the 2nd day and sacrified on the 7th day. Intratracheal instillation of Ca-DTPA brought about a significant decrease in lung retention of Fe-59 and a marked increase in urinary excretion of Fe-59. Although intratracheal instillation of H-5 DTPA significantly increased urinary excretion of Fe-59, its effectiveness was about half that of Ca-DTPA. Furthermore, H-5 DPTA was given by subcutaneous implantation and Ca-DTPA was given by intraperitoneal injection following intravenous injection of Fe-59 iron dextran. Tissue distribution of Fe-59 did not differ greatly in the two chelating agents. The excretion of Fe-59 into the feces was approximately 7 times higher in the group treated with H-5 and Ca-DTPA than the control group. Regarding fecal excretion, the effect of H-5 DTPA was the same as that of Ca-DTPA. Urinary excretion was greatly influenced by H-5 DTPA treatment, being 3.4 times higher than by Ca-DTPA treatment. (Namekawa, K).

8579 (PNL–6696-HEDR-Rev.1) **Work plan for the Hanford Environmental Dose Reconstruction Project: Revision 1.** Pacific Northwest Lab., Richland, WA (USA). Dec 1989. 121p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC06-76RL01830. Order Number DE90004036. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The primary objective of the Hanford Environmental Dose Reconstruction (HEDR) Project is to estimate the radiation doses that populations could have received from nuclear operations at the Hanford Site since 1944, with descriptions of uncertainties inherent in such estimates. The secondary objective is to make project records–information that HEDR staff members used to estimate radiation doses–available to the public. Preliminary dose estimates for a limited geographic area and time period, certain radionuclides, and certain populations are planned to be available in 1990; complete results are planned to be reported in 1993. Project reports and references used in the reports are available to the public in the DOE Public Reading Room in Richland, Washington. Project progress is documented in monthly reports, which are also available to the public in the DOE Public Reading Room.

8580 **External radiation carcinogenesis.** Fry, R.J.M. (Biology Div., Oak Ridge National Lab., Oak Ridge, TN); Storer, J.B. pp. 405 of Advances in radiation biology. Volume 13. Lett, J.T Academic Press Complimentary Copy Coordinator, Marketing Dept., San Diego, CA (1987). DOE Contract AC05-84OR21400.

There have been many reviews of the subject of radiation carcinogenesis in general and of specific radiation-induced cancers. The aim of this article is not to give an exhaustive, and perhaps exhausting, review of all that has been published since the thorough treatise of Walburg in volume 4 of this series but rather to concentrate on the questions that still remain of importance and recent contributions to the answers. In the years since 1974 a vast amount of information has been reported, and the authors assess what gain there has been in knowledge. For example, it is in the 13 years since the last review that the great majority of data for the carcinogenic effects of neutrons has appeared. It is over 50 years since the discovery of the neutron, and yet knowledge of the carcinogenic effects of neutrons is far from adequate.

8581 **Wavelength dependence of pyrimidine dimer formation in DNA of human skin irradiated in situ with ultraviolet light.** Freeman, S.E. (Brookhaven National Laboratory, Upton, NY (USA)); Hacham, H.; Gange, R.W.; Maytum, D.J.; Sutherland, J.C.; Sutherland, B.M. *Proceedings of the National Academy of Sciences of the United States of America (USA),* 86(14): 5605-5609 (Jul 1989).

The UV components of sunlight are believed to be a major cause of human skin caner, and DNA is though to be the principal molecular target. Alterations of the intensity and wavelength distribution of solar UV radiation reaching the surface of the earth, for example by depletion of stratospheric ozone, will change the effectiveness of solar radiation in damaging DNA in human skin. Evaluation of the magnitude of such effects requires knowledge of the altered sunlight spectrum and of the action spectrum for damaging DNA in human skin. The authors have determined an action spectrum for the frequency of pyrimidine dimer formation induced in the DNA of human skin per unit dose of UV incident on the skin surface. The peak of this action spectrum is near 300 nm and decreases rapidly at both longer and shorter wavelengths. The decrease in the action spectrum for wavelengths <300 nm is attributed to the absorption of the upper layers of the skin. Convolution of the dimer action spectrum with the solar spectra corresponding to a solar angle of 40° under current levels of stratospheric ozone and those for 50% ozone depletion, indicate about a 2.5-fold increase in dimer formation. If the action spectrum for DNA damage that results in skin cancer resembles that for dimer induction in skin, these results suggest that a 50% decrease in stratospheric ozone would increase the incidence of nonmelanoma skin cancers among white males in Seattle, Washington, by 7.5- to 8-fold, to a higher incidence than is presently seen in the corresponding population of Albuquerque, New Mexico.

5602 Thermal Effects

Refer also to citation(s) 7164, 8507

8582 **Retention of photosynthetic activity in spinach chloroplast after stress.** Jun, Sungsoo (Brandeis Univ., Waltham, MA (USA)); Fu, Cheefook; Gibbs, M. pp. 269 of Plant senescence: its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

The ability for isolated spinach chloroplasts to fix CO_2 was reduced by 50% after heat stress. A pH-dependency was revealed for the reduction of CO_2 fixation as it was augmented by low pH. Neither the thylakoid or stroma was affected when the intact chloroplasts were stresses at pH 8, but at pH 6, the thylakoid functions were reduced, as indicated by the CO_2 fixation of a reconstituted chloroplast system, photophosphorylation, and NADP reduction. In isolated form, thylakoids were very susceptible to heat stress, while the stroma was quite stable. The levels of ATP, ADP, and NADP inside the chloroplast were decreased by heat stress, while AMP and NAD were increased. This was thought to be due to the activation of the stroma acid phosphatase since the activity of this enzyme toward these substrates was greatly increased at pH 6, compared with that at pH 8. Thus, the decrease of ATP and ADP appeared to be the primary cause of the reduction in CO_2 fixation by heat stress. All of the inhibitory effect of heat stress can be overcome by the addition of Mg-ATP or FBP with oxaloacetic acid and aldolase during stress.

5603 Chemicals Metabolism and Toxicology

Refer also to citation(s) 6767, 7173, 8380, 8444, 8499

8583 (CONF-8906180–3) **The food chain as a source of human exposure from municipal waste combustion: An uncertainty analysis.** Belcher, G.D. (Oak Ridge National Lab., TN (USA)); Travis, C.C.; Bruins, R.J.F. Oak Ridge National Lab., TN (USA). [1989]. 73p. Sponsored by Environmental Protection Agency. DOE Contract AC05-84OR21400. From U.S. EPA/ORNL workshop on municipal waste combustion: deposition, food chain impacts, uncertainty, and research needs; Cincinnati, OH (USA); 8-9 Jun 1989. Order Number DE90003671. Available from NTIS, PC A04/MF A01 - OSTI; GPO Dep.

The current installed incineration capacity of municipal waste combustors (MWCs) in the United States has reached approximately 50 thousand tons per day and is projected to triple over the next decade. As the use of MWCs as a waste management alternative has increased, public concern over possible environmental and

human health effects has also increased. Of particular concern are health risks associated with potential exposures through the food chain. The food chain is the primary pathway of human exposure for a large class of organics, such as dioxin, PCBs, DDT, and other pesticides. Because many pollutants emitted by MWCs are lipophilic, extremely persistent compounds, they tend to sorb strong to air particles, soil, and sediment and to bioaccumulate in living organisms. As a result, the food chain can be a major pathway of exposure to pollutants emitted by MWCs. It is the purpose of this paper to assess the magnitude of human exposure through the food chain for two pollutants released by MWCs: cadmium and 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), commonly referred to as dioxin. These pollutants were chosen as representative of two chemical classes: metals and organics. Cadmium is a metal which presumably will enter the food chain primarily through vegetative root uptake, while dioxin is an extremely lipophilic compound which will bioconcentrate in beef and milk. 57 refs., 7 figs., 14 tabs.

8584 (CONF-8911148–1-Vugraphs) **Short-term bioassays may be useful in evaluating fiber/whisker hazards.** Easterly, C.E. Oak Ridge National Lab., TN (USA). [1989]. 27p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. From ASTM Subcommittee meeting; Orlando, FL (USA); 28-29 Nov 1989. Order Number DE90003707. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The utility of short-term bioassays for predicting hazards has been the focus of many individual efforts in the past. The World Health Organization concludes that a combination of tests may be useful in detecting excess formation of fibrous tissue in the lung as a result of reparative or reactive processes. Further, some consistency has been observed between specific in vitro assays and the induction of mesotheliomas induced in in vivo assays. For the most part such studies of correlation were very qualitative and were performed using mechanistic concepts to "match" the in vitro studies with whole animal studies. An alternative method to viewing the in vitro to in vivo correlation will be presented in this talk. Much of the focus will be on work performed by L. R. Glass during his dissertation research. Based on the alternative method, a plan for testing this concept on fibers will be presented. The abstract is this paper's only test; the remainder consists of viewgraphs.

8585 (ETDE-mf–0728785) **Effects of pollutants on the primary processes of photosynthesis. Final report.** Renger, G.; Graeber, P. Technische Univ. Berlin (Germany, F.R.). Max-Volmer-Institut fuer Biophysikalische und Physikalische Chemie; Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.). Apr 1988. 33p. (In German). Contract BMFT 03 7410 3. Order Number DE90728785. Available from NTIS (US Sales Only), PC A03/MF A01.

Different air pollutants diminish the photosynthetic efficiency of plants. In this work the effect of ozone and sulphur-dioxide on the primary processes of photosynthesis was investigated. The chlorophyll fluorescence was measured in control plants and treated plants (beans, spinach) by using a computer-controlled fluorometer. The analysis of the measured fluorescence induction curves gives data on the type and on the degree of inhibition of photosynthesis. After treatment with ozone and sulphur-dioxide acute inhibition of the primary processes of photosynthesis is observed. This leads to a diminished efficiency of conversion of light energy into stable photosynthetic products (e.g. starch). However, these effects occur in a concentration range which is about one order of magnitude higher than found in strongly polluted air. The method developed here can be used for fast and non-damaging detection of inhibition of the photosynthetic apparatus. Moreover, it allows conclusions about the type and degree of inhibition. (orig.) With 28 refs., 1 tab., 16 figs.

8586 (KVM–19) **Chlorinated hydrocarbons: Compilation of information from a seminar 19 May 1988.** KVM, the Joint Committee of Power and Heating Producers on Environmental Issues, Stockholm (Sweden). Jan 1989. 34p. (In Swedish). (CONF-8805344–: Chlorinated hydrocarbons conference, Stockholm (Sweden), 19 May 1988). Order Number DE90728270. Available from NTIS (US Sales Only), PC A03/MF A01.

Four lectures were given under the following headings: * Environmental poisons: From where and where to?, * Will fish consumers survive? A presentation of environmental poison research on fish-consuming mammals, * Factors influencing the assimilation of hydrophobic organic compounds in fish, * DDT, PCB, dioxin, - - - A survey in an environmental chemistry perspective. A separate abstract was prepared for the last topic. (With 21 figures and 5 tables).

8587 (ORNL/M–975-Vol.1) **The Installation Restoration Program Toxicology Guide: Volume 1.** Oak Ridge National Lab., TN (USA). Jul 1989. 672p. Sponsored by U.S. Department of Defense. DOE Contract AC05-84OR21400. Order Number DE90003931. Available from NTIS, PC A99/MF A01 - OSTI; GPO Dep.

One of the objectives of the US Air Force Installation Restoration Program (IRP) is to provide individuals responsible for the management and implementation of the IRP with information to evaluate the health hazards associated with actual or potential contamination of drinking water supplies. This IRP Toxicology Guide consists of four volumes which were initially issued in 1985-1987. The updated volumes of the Toxicology Guide include new regulatory requirements and recently published toxicology information. The updated Toxicology Guide was produced under an Interagency Agreement with the US Department of Energy, Oak Ridge National Laboratory for the Hazard Assessment Branch, Toxic Hazards Division, AAMRL, Wright-Patterson AFB, OH. For each chemical in the IRP Toxicology Guide, the environmental fate, exposure pathways, toxicity, sampling and analysis methods and state and federal regulatory status are outlined. The material provided is intended as an overview of key topic areas; no attempt was made to provide a comprehensive review. Users are encouraged to read the Introduction to Volume 1 of the IRP Toxicology Guide before applying chemical-specific information. Candidate chemicals for inclusion in subsequent Toxicology Guide updates should be forwarded through MAJCOM bioenvironmental engineers to HQ USAF/SGPA. 7 figs., 20 tabs.

8588 (ORNL/M–975-Vol.2) **The Installation Restoration Program Toxicology Guide: Volume 2.** Oak Ridge National Lab., TN (USA). Jul 1989. 716p. Sponsored by U.S. Department of Defense. DOE Contract AC05-84OR21400. Order Number DE90003932. Available from NTIS, PC A99/MF A01 - OSTI; GPO Dep.

One of the objectives of the US Air Force Installation Restoration Program (IRP) is to provide individuals responsible for the management and implementation of the IRP with informtion to evaluate the health hazards associated with actual or potential contamination of drinking water supplies. The Harry G. Armstrong Aerospace Medical Research Laboratory was requested by HQ USAF/SGPA to develop health and environmental information for each potential contaminant of drinking water supplies associated with USAF installations. This IRP Toxicology Guide consists of four volumes which were initially issued in 1985-1987. The original Toxicology Guide was produced under contract F33615-81-D-0508 by Arthur D. Little, Inc. for the Biochemical Toxicology Branch, Toxic Hazards Division, Harry G. Armstrong Aerospace Medical Research Laboratory (AAMRL), Wright-Patterson AFB, OH. The updated volumes of the Toxicology Guide include new regulatory requirements and recently published toxicology information. The updated Toxicology Guide was produced under an Interagency Agreement with the US Department of Energy, Oak Ridge National Laboratory (87-TH-0002) for the Hazard Assessment Branch, Toxic Hazards Division, AAMRL, Wright-Patterson AFB, OH. For each chemical in the IRP Toxicology Guide, the environmental fate, exposure pathways, toxicity, sampling and analysis methods and state and federal regulatory status are outlined. The material provided is intended as an overview of key topic areas; no attempt was made to provide a comprehensive review. Users are encouraged to read the Introduction to Volume 1 of the IRP Toxicology Guide before applying chemical-specific information.

8589 (ORNL/M–975-Vol.4) **The installation restoration program toxicology guide: Volume 4.** Lu, Po-Yung. Oak Ridge National Lab., TN (USA). Jul 1989. 739p. Sponsored by U.S. Department of Defense. DOE Contract AC05-84OR21400. Order Number DE90003934. Available from NTIS, PC A99/MF A01 - OSTI; GPO Dep.

One of the objectives of the US Air Force Installation Restoration Program (IRP) is to provide individuals responsible for the management and implementation of the IRP with information to evaluate the health hazards associated with actual or potential contamination of drinking water supplies. This IRP Toxicology Guide consists of four

volumes which were initially issued in 1985–1987. Updated volumes of the Toxicology Guide include new regulatory requirements and recently published toxicology information. For each chemical in the IRP Toxicology Guide, the environmental fate, exposure pathways, toxicity, sampling and analysis methods and state and federal regulatory status are outlined. The material provided is intended as an overview of key topic areas; no attempt was made to provide a comprehensive review. Users are encouraged to read the Introduction to Volume 1 of the IRP Toxicology Guide before applying chemical-specific information.

8590 Differential turnover of chloroplast proteins and membrane association of ribulose-1,5-bisphosphate carboxylase subunits during copper-induced senescence of Spirodela plants. Mattoo, A.K. (Beltsville Agricultural Research Center, MD (USA)); Mehta, R.A.; Conlon, C.A.; Porath, D. pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Pulse-labeling and pulse-chase experiments in conjunction with analysis of immunoblots of specific chloroplast proteins have indicated specific effects of copper ions on turnover of chloroplast-located proteins. The steady-state levels of large and small subunits of ribulose-1,5-bisphosphate carboxylase (Rubisco), large subunit-binding protein, the 32 kD PSII protein and β-subunit of proton ATPase decreased within 4 h of incubation with excess copper ions, while those of plastocyanin, 33 kD PSII extrinsic protein, 26 kD chlorophyll a/b-binding apoprotein, and subunit I of PSI did not show any marked charge. Copper-mediated senescence resulted in the disappearance of Rubisco subunits from the stroma, concomitant with their association with the cellular membranes. Pulse-chase experiments revealed a lag period of 4 to 8 h in the association of newly synthesized Rubisco subunits with the membranes indicating a finite time for their location on the membranes. Two degradation products of the small subunit of Rubisco were also identified: only the mature, undegraded form of the small subunit was seen associated with the membranes. They are concentrating their studies on the mechanism(s) involved in the membrane association of Rubisco subunits and in understanding the process of differential turnover of chloroplast proteins during higher plant senescence.

8591 Lithium perturbation of membrane transport and leaf disc senescence. Madore, M.A. (Univ. of California, Riverside (USA)). pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Of particular interest to the present study is the observation that the aging phenomenon can apparently be inhibited by treatment of excised leaf discs with lithium. Lithium is a known inhibitor of the phosphoinositide signalling mechanism in animal tissues, preventing the hydrolysis of inositol-I-P to myo-inositol and inorganic phosphate. The recent demonstration that plant microsomal membranes show an inositol-1,4,5-trisphosphate dependent release of calcium suggests that this signalling system is also active in plant tissues, and therefore may be operative in the reestablishment of membrane transport function in excised leaf discs. Since it is known from studies on animal tissues that the inhibitory effects of lithium can be overcome by treatment with myo-inositol, it was of interest in the present study to determine if the lithium inhibition of the membrane transport repair processes in plant tissues could also be overcome by myo-inositol. In Ipomoea tricolor, Li greatly reduced the loss of chlorophyll from excised leaf discs, indicating a possible role of phosphatidylinositol in long-term senescence events. On a more short-term scale, a recovery of membrane transport of sucrose was evident by 3 h following excision of the leaf discs but lithium eliminated the enhancement of uptake almost entirely. The aging phenomenon was not specific for sucrose but was also seen for uptake of glucose and glycine. Lithium greatly reduced the enhanced uptake induced by aging, but the aging effect was almost completely restored by treatment with myo-inositol.

8592 Ultrastructural studies of naturally senescing Phaseolus vulgaris. I. Leaves and their comparison with the alterations induced by particulate pollutants (bauxite and cement dusts) in Phaseolus vulgaris L. Amaranthus dubius Mart leaves. Dixit, A. (Univ. of West Indies, Kingston (Jamaica)). pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

Ultrastructural studies of Phaseolus vulgaris L. leaves at various stages of senescence provided a good comparison with the alterations induced by particulate pollutants (bauxite and cement dusts) in Phaseolus vulgaris L. and Amaranthus dubius Mart. Leaves. The dusted leaves exhibited some or most of the ultrastructural alterations observed during natural senescence. These leaves also showed alterations due to the activation of wound repair and/or defense mechanisms in the cells. In addition, stress-related alterations were observed in the bauxite-dusted P. vulgaris leaves. The presence of characteristics similar to those occurring during natural senescence indicated that the defense and/or repair mechanisms were not completely effective, and they eventually gave in to premature senescence.

8593 Carbon dioxide exchange characteristics of Zea mays L. leaves subsequent to full leaf expansion: Effect of nitrogen content. Williams, L.E. (Louisiana State Univ., Baton Rouge (USA)). pp. 269 of Plant senescence: Its biochemistry and physiology. Thomson, W.W.; Nothnagel, E.A.; Huffaker, R.C. (eds.) American Society of Plant Physiologists, Rockville, MD (US) (1987). (CONF-8701163–: 10. annual symposium in plant physiology: plant senescence: its biochemistry and physiology, Riverside, CA (USA), 6-10 Jan 1987).

A linear relationship between net CO_2 assimilation rate (A) and leaf N has been demonstrated during leaf senescence of several C_3 species. The purpose of this study was to determine the relationship between A and leaf N of the C_4 plant, Zea mays L., between full leaf expansion and death. Age and N content varied by sampling leaves from the top of the plant sequentially down the stem. In addition, the effect of photosynthetic photon fluence rate (PPFR) and intercellular CO_2 concentration (c_i) on A, and stomatal conductance (g_s) of similarly aged leaves were measured. Measurements (on plants that had been grown outdoors) commenced subsequent to flowering, a time in which all leaves on the plant were fully expanded. The distal portion of each leaf (approximately 10 cm in length) was used for all measurements.

8594 Thallium safety. Myers, G.E. (Argonne National Lab., IL (USA)). *Superconductor Industry (USA)*, 1(2): 13-19 (1988).

This article details the risks of working with thallium and the methods for minimizing those risks. The author discusses thallium toxicity in the work environment and compared to other toxic materials; specified handling methods; and stresses employee education. The properties of thallium which make it an attractive material to work with are also described.

8595 Elemental analyses of Cd-treated Laminaria saccharina. Chung, I.K. (Brookhaven National Lab., Upton (USA)); Brinkhuis, B.H.; Schdlovsky, G. *Journal of Phycology (USA)*, 23: 83 (Jun 1987). (CONF-8708345–: Annual meeting of the Phycological Society of America, Columbus, OH (USA), 9-13 Aug 1987).

Elemental analyses were applied to Cd-treated Laminaria saccharina with various sample preparation methods and different detection systems on bulk and thin section specimens. Air-drying, critical-point drying and freeze-fracturing were used in sample preparation and energy dispersive x-ray microanalysis (EDS) and synchrotron radiation induced x-ray emission (SRIXE) methods were used for detection. The concentration level of Cd seemed too low to be detected under the EDS system with air-dried, critical-point dried and freeze-fractured bulk samples, despite tissue incubations in 10^{-4} M for 48 hr. There were no indications of tightly bound subcellular Cd localization in thin sections of plastic embedded tissues with the EDS method. However, Cd could be identified with the SRIXE technique in air-dried bulk samples. The present study determined that sample preparation methods are very important in determining the presence of elements.

8596 **Chlorambucil effectively induces deletion mutations in mouse germ cells.** Russell, L.B. (Oak Ridge National Laboratory, TN (USA)); Hunsicker, P.R.; Cacheiro, N.L.A.; Bangham, J.W.; Russell, W.L.; Shelby, M.D. *Proceedings of the National Academy of Sciences of the United States of America (USA)*, 86(10): 3704-3708 (May 1989).

The chemotherapeutic agent chlorambucil was found to be more effective than x-rays or any chemical investigated to data in inducing high yields of mouse germ-line mutations that appear to be deletions or other structural changes. Induction of mutations involving seven specific loci was studied after exposures of various male germ-cell stages to chlorambucil at 10-25 mg/kg. A total of 60,750 offspring was scored. Mutation rates in spermatogonial stem cells were not significantly increased over control values; this negative result is not attributable to selective elimination of mutant cells. Mutations were, however, clearly induced in treated post-stem-cell stages, among which marked variations in mutational response were found. Maximum yield occurred after exposure of early spermatids, with ≈ 1% of all offspring carrying a specific-locus mutation in the 10 mg/kg group. The stage-response pattern for chlorambucil differs from that of all other chemicals investigated to date in the specific-locus test. Thus far, all but one of the tested mutations induced by chlorambucil in post-stem-cell stages have been proved deletions or other structural changes by genetic, cytogenetic, and/or molecular criteria. Deletion mutations have recently been useful for molecular mapping and for structure-function correlations of genomic regions. For generating presumed large-lesion germline mutations at highest frequencies, chlorambucil may be the mutagen of choice.

8597 **Effect of manganese ions on the incorporation of dideoxynucleotides by bacteriophage T7 DNA polymerase and Escherichia coli DNA polymerase I.** Tabor, S. (Harvard Medical School, Boston, MA (USA)); Richardson, C.C. *Proceedings of the National Academy of Sciences of the United States of America (USA)*, 86(11): 4076-4080 (Jun 1989).

Incorporation of dideoxynucleotides by T7 DNA polymerase and Escherichia coli DNA polymerase I is more efficient when Mn^{2+} rather than Mg^{2+} is used for catalysis. Substituting Mn^{2+} for Mg^{2+} reduces the discrimination against dideoxynucleotides approximately 100-fold for DNA polymerase I and 4-fold for T7 DNA polymerase. With T7 DNA polymerase and Mn^{2+}, dideoxynucleotides and deoxynucleotides are incorporated at virtually the same rate. Mn^{2+} also reduces the discrimination against other analogs with modifications in the furanose moiety, the base, and the phosphate linkage. A metal buffer, isocitrate, expands the $MnCl_2$ concentration range effective in catalyzing DNA synthesis. The lack of discrimination against dideoxynucleoside triphosphates using T7 DNA polymerase and Mn^{2+} results in uniform terminations of DNA sequencing reactions, with the intensity of adjacent bands on polyacrylamide gel varying in most instances by less than 10%.

5604 Other Environmental Pollutant Effects

Refer also to citation(s) 7581, 7746

8598 (CONF-8608233–8) **Electric and magnetic fields from power transmission systems. Results of an international survey.** Britten, A.; Cortina, R.; Gary, C. Ente Nazionale per l'Energia Elettrica, Milan (Italy). Aug 1986. 7p. From CIGRE international conference on large high voltage electric systems; Paris (France); 27 Aug - 4 sep 1986. Order Number DE89761886. Available from NTIS (US Sales Only), PC A02/MF A01.

Paper presented at international conference on large high voltage electric systems (Paris, 27 Aug-4 Sep 1986).

In 1984, Study Committee 36 (Interference) decided to initiate an international survey amongst the member countries of this Committee. The question was to have general information about the way public opinion perceives and reacts upon construction or presence of transmission systems (overhead lines and substations), and about the way network operators handle such problems. More specific emphasis was put on those problems associated with the existence of electric fields and on research carried out in that area. This report aims to summarize the replies. All twenty-one member countries of Committee 36 took part in the survey, thus showing the interest aroused worldwide by a comparative survey of such wide scope.

57 HEALTH AND SAFETY

Refer also to citation(s) 7051

8599 (KFA-ASS–0493) **1988 annual work report of the Department for Safety and Radiation Protection.** Hille, R. (ed.). Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Abt. Sicherheit und Strahlenschutz. Mar 1989. 242p. (In German). Order Number DE90732545. Available from NTIS (US Sales Only), PC A11/MF A01.

The Department for Safety and Radiation Protection continues to be responsible for coordinating radiation protection, safety and protection at the KFA. It supports the other institutes and departments in performing the safety tasks allotted to them. The principal tasks of the Department are in administrative and technical assistance to these organization units and in safeguards. Administrative assistance involves, for example, regulation of the radiation protection organization in the institutes, including the appointment of radiation protection officers (Strahlenschutzbeauftragte). Furthermore, this includes the central handling of the registration system with the authorities and dealing with outside firms thus considerably relieving the institutes of their administrative tasks. Handling licensing procedures and the central accountancy of radioactive materials is also to be mentioned in this context. Technical assistance largely consists of developing, maintaining and repairing radiation measuring instruments and in the monitoring of personnel by evaluating personnel dosimeters and incorporation controls for radioactive sources. The safeguards tasks of the Department concern the very staff-intensive physical protection, as well as environmental protection and industrial safety. (orig.).

58 GEOSCIENCES

Refer also to citation(s) 6971, 6974, 7041, 7107, 7233, 7248, 7251, 7252, 7272, 7282, 7292, 7294, 7300, 7304, 7326, 7327, 7328, 7329, 7331, 7335, 7337, 7343, 7344, 7349, 7350, 7351, 7352, 7353, 7354, 7355, 7495, 8096, 8191

8600 (DOE/ER–0430) **Summaries of physical research in the geosciences.** USDOE Office of Energy Research, Washington, DC (USA). Engineering and Geosciences Div. Dec 1989. 148p. Sponsored by U.S. DOE Energy Research. Order Number DE90004993. Available from NTIS, PC A08/MF A01 - OSTI; GPO Dep.

The Department of Energy supports research in the geosciences in order to provide a sound foundation of fundamental knowledge in those areas of the geosciences which are germane to the Department of Energy's many missions. The Division of Engineering and Geosciences, part of the Office of Basic Energy Sciences of the Office of Energy Research, supports the Geosciences Research Program. The participants in this program include Department of Energy laboratories, industry, universities, and other governmental agencies. These activities are formalized by a contact or grant between the Department of Energy and the organization performing the work providing funds for salaries, equipment, research materials, and overhead. The summaries in this document, prepared by the investigators, describe the scope of the individual programs. The Geoscience Research Program includes in geology, petrology, geophysics, geochemistry, solar physics, solar-terrestrial relationships, aeronomy, seismology, and natural resource modeling and analysis, including their various subdivisions and interdisciplinary areas. All such research is related either or indirectly to the Department of Energy's long-range technological needs.

8601 (DOE/ER/13770–T1) **Residence time distribution approach to the study of free convection in porous media.** Jones, M.C.; Perkins, R.A. National Bureau of Standards, Boulder, CO (USA). Chemical Engineering Science Div. 8 Jun 1988. 8p. Sponsored by U.S. DOE Energy Research. DOE Contract AI05-87ER13770. Order Number DE90003848. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

In this project the object is to apply the principles of Residence Time Distribution (RTD) analysis to the study of free convection in porous media. The advantages of this technique are that it is non-intrusive, the data are quickly generated, and a large amount of

information, distributed in the time domain, is obtained. The disadvantage is that a model must be used to infer the flow pattern from the RTD. It is proposed to apply the same modeling approaches that have been used successfully in mixing tank studies and to interpret the flow patterns in terms of similar mixing tank model parameters. Correlations would then be sought with global parameters of the porous medium like Rayleigh, Peclet and Nusselt numbers. 2 refs., 3 figs.

8602 (EPRI-NP–6593) **The New Zealand earthquake of March 2, 1987: Effects on electric power and industrial facilities: Final report.** Electric Power Research Inst., Palo Alto, CA (USA); EQE Engineering, Inc., San Francisco, CA (USA). c Nov 1989. 234p. Sponsored by Electric Power Research Institute. Available from Research Reports Center, Box 50490, Palo Alto, CA 94303.

The Bay of Plenty region of the northern island of New Zealand was struck by a magnitude 6.3 earthquake on March 2, 1987. The region is a center of large industrial operations for the production of paper and agricultural products. A modern high-voltage electric power system serves the area. The local soil conditions and the complicated faulting mechanism of the earthquake combined to create very intense ground shaking in the vicinity of some of the power and industrial facilities. The effects of the earthquake in some locations were the most severe yet encountered in the post-earthquake investigation program sponsored by EPRI. Extensive damage occurred in substation switchyards, in spite of well-engineered provisions for seismic loads. Industrial operations suffered substantial financial losses from the earthquake, again in spite of generally good seismic design provisions in structures. The earthquake provides excellent illustrations of the seismic fragility of certain equipment and structures common to electric power installations. It also reinforces previous experience regarding the seismic durability of most equipment critical to the safe operation of power plants, nuclear plants in particular. 30 refs., 132 figs., 3 tabs.

8603 (GRSJ–8901, pp. 63-64) **Mineralogical and geochemical characteristics of hydrothermally altered basalt in the Kuroko mining area, Japan. Comparison with ridge basalt alteration.** Shikazono, N. (Univ. of Tokyo (Japan)); Shimizu, M.; Utada, M. Geothermal Research Society of Japan, Tsukuba (Japan). 10 Nov 1988. (CONF-881170–: International symposium on geothermal energy, Kumamoto (Japan), 10-14 Nov 1988). In *Exploration and development of geothermal resources.* Order Number DE89782366. Available from NTIS (US Sales Only), PC A99/MF A01.

The hydrothermally altered basalt in the Kuroko mining area can be mineralogically divided into chlorite-rich and epidote-rich one. It is stressed that the vesicle of the chlorite-rich type is filled with chlorite, whereas the vesicle of the epidote-rich one is filled with epidote, quartz, calcite and small amounts of hematites and magnetite. In general, brecciated rock suffered the chlorite-rich type alteration, whereas massive rock is changed to the epidote-rich one. Fluid inclusion studies show that alteration of basalt to the chlorite-rich and epidote-rich assemblages occurred at the temperature range of 230-250 C and 250-280°C, respectively. The above data indicate that permeability and temperature are important factors causing different type of alteration. Stable isotope data (unit:10^{-3}) of the altered Kuroko basalt ($\delta\,^{13}C$ of calcite : -8 to -3, $\delta\,^{18}O$ of calcite : +6 to +12) show good accordance to those of the altered ridge basalt ($\delta^{13}C$ of calcite:-7 to -3, $\delta^{18}O$ of calcite:+7 to +12). However, the altered Kuroko basalt provides some differences in comparison with the altered ridge basalt (CaO; lower, Fe_2O_3 and Na_2O; higher and so on). The original rock composition is considered to be the most probable cause for explanations. 1 tab.

8604 (GS–89-1G) **Current research, part G. Frontier geoscience program, Arctic Canada.** Geological Survey of Canada, Ottawa, ON (Canada). 1989. 280p. (MICROLOG–89-03293). Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

Canada's Frontier Geoscience Program has the general objective of ascertaining the geological history and development of all sedimentary basins offshore and in the north where oil and gas resources might occur. To facilitate management of the program, it has been divided into four regions, and current research papers on one of these regions, the Arctic, are presented in this report. Subjects of the papers include stratigraphy, thermal maturation, fossil studies, geochemistry, geothermal gradients, and hydrocarbon potential. Separate abstracts have been prepared for 12 papers from this report.

8605 (GS–89-1G, pp. 77-84) **Lower Paleozoic of the White Mountains, Yukon and Northwest Territories, and sedimentological evidence for the existence of a White Mountains platform.** Morrow, D.W. (Inst. of Sedimentary and Petroleum Geology, Calgary, AB (Canada)). Geological Survey of Canada, Ottawa, ON (Canada). 1989. (MICROLOG–89-03293). In *Current research, part G. Frontier geoscience program, Arctic Canada.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

The Ordovician to Devonian stratigraphic sequence exposed in the White Mountains of northern Yukon Territory indicates the possibility of a major change in regional paleogeography following deposition of the Ordovician to Silurian Vunta Formation. The undolomitized, high energy, carbonate grainstone deposits of the Vunta Formation are consistent with deposition on a small White Mountains Platform separated from the coeval, dolomitized eastern carbonate shelf sequence. In contrast, the overlying unnamed Upper Silurian and the Devonian Kutchin and Ogilvie formations are very similar to their coeval counterparts on the eastern carbonate shelf. Regressive cycles in the Ogilvie formations are very similar to their coeval counterparts on the eastern carbonate shelf. Regressive cycles in the Ogilvie Formation resemble similar cycles in the Arnica and Landry formations farther east. Unconformities in this part of the White Mountains lower Paleozoic sequence are present in both of these regions. These similarities may indicate that from Late Silurian to Devonian time, the White Mountains Platform was in reality a peninsula and part of the eastern lower Paleozoic carbonate shelf. This research raises the possibility of the existence of Silurian-Devonian carbonate strata in the subsurface in the region between the White Mountains and the eastern lower Paleozoic carbonatre shelf, which might provide an additional potential exploration target for hydrocarbon reservoirs in the northern Yukon Territory. 11 refs., 4 figs.

8606 (GS–89-1G, pp. 69-76) **Preliminary report on Ordovician-Devonian conodont collections from carbonate and fine grained clastic facies of northern Yukon Territory and northwest District of Mackenzie, N.W.T.** McCracken, A.D. (Inst. of Sedimentary and Petroleum Geology, Calgary, AB (Canada)). Geological Survey of Canada, Ottawa, ON (Canada). 1989. (MICROLOG–89-03293). In *Current research, part G. Frontier geoscience program, Arctic Canada.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

Conodont collections provide the data necessary for detailed taxonomic studies, which will improve the accurate dating and correlation of strata in Canadian sedimentary basins and thus contribute to the assessment of strata for hydrocarbon exploration. In 1986-88, 361 conodont samples were collected from 30 sections of the fine grained clastic (Road River Group) and generally unnamed carbonate facies of northern northwestern Canada in order to study conodont evolution in trough and platform settings, to refine conodont biostratigraphy, and integrate the conodont and graptolite zonal schemes. Only one third of the data has been processed, yielding over 23,076 diverse conodont elements ranging in age from Ordovician through Devonian. Ordovician conodonts range in age from Early Arenig to late Richmondian. Ordovician faunas from Blackstone River, Prongs Creek and Churchward Amnticline are of particular interest. Some of the faunas and zones include: Paracordylodus fauna, O. sesquipedalis fauna, P. serra Zone, G. ensifer Zone. Silurian faunas and zones recognized at Prongs Creek, Illtyd Range, and Pai Lake tentatively include the D. kentuckyensis, P. celloni and P. amorphognathoides zones, and the O.n./A-I./.B, and O. fluegeli faunas. Ludlow-Lockovian conodonts are recognized at

Illtyd Range Beds at Royal Creek have yielded Upper Silurian-Lower Devonian Conodonts. 31 refs., 1 fig., 1 tab.

8607 (GS–89-1G, pp. 63-67) **Comparison of the geothermal and organic maturation gradients of the central and southwestern Beaufort-Mackenzie Basin, Yukon and Northwest Territories.** Majorowicz, J.A. (Univ. of Alberta, AB (Canada)); Dietrich, J.R. Geological Survey of Canada, Ottawa, ON (Canada). 1989. (MICROLOG–89-03293). In *Current research, part G. Frontier geoscience program, Arctic Canada.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

The geothermal regime of the Beaufort-Mackenzie Basin is being studied through the analysis of bottom-hole temperature and net rock data from 34 petroleum exploration wells in the basin. The heat flow and geothermal gradient calculations from this study have been compared with organic maturation data (Vitrinite reflectance measurements) from 8 of the 34 wells. Data from the Yukon coastal plain and central Mackenzie Delta indicate that both areas are characterized by low geothermal gradients and heat flow, and near-identical organic maturation gradients, but substantially different absolute maturation levels. The maturation level difference between the two areas is believed to be the result of erosional processes rather than intrabasinal paleogeothermal variations. In particular, maturation data and those resulting from regional geological studies indicate that 6 to 7 km of strata have been eroded from the Yukon coastal plain area. 22 refs., 3 figs.

8608 (GS–89-1G, pp. 101-104) **Thermal maturity of Lower Carboniferous rocks in northern Yukon Territory.** Utting, J. (Inst. of Sedimentary and Petroleum Geology, Calgary, AB (Canada)). Geological Survey of Canada, Ottawa, ON (Canada). 1989. (MICROLOG–89-03293). In *Current research, part G. Frontier geoscience program, Arctic Canada.* Available from PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN.

Analysis of palynomorphs and organic matter indicate that the thermal alteration index is high (TA1 3+ to 5) in the Lower Carboniferous Kayak Formation of the British Mountains and Barn Range; low (TA1 2 to 2+) in the Ford Lake and Hart River formations of the southeastern part of Eagle Plain where many samples contain amorphous kerogen; medium (TA1 3+) in the southern subsurface of Eagle Plain (Hart River Formation), and low to medium (TA1 2- to 3+) in the western Ogilvie Mountains (Hart River and Blackie formations). The high thermal maturity, along with the presence of anthracitic coal seams in the Hoidahl Dome, suggests a good potential for gas generation in the Lower Carboniferous strata in the British Mountains and Barn Range. To the south of Eagle Plain, the thermal maturity, at least in some areas, is very low, suggesting that in places there was no significant depth of burial. These areas may well contain liquid hydrocarbon source rocks, especially in view of the abundant amorphous organic matter in the Hart River Formation. 8 refs., 1 fig., 2 tabs.

8609 (IC–89/81) **Seismicity and tectonics of Bangladesh.** Hossain, K.M. International Centre for Theoretical Physics, Trieste (Italy). May 1989. 26p. Order Number DE90610795. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

Northern and eastern Bangladesh and surrounding areas belong to a seismically active zone and are associated with the subduction of the Indian plate. The seismicity and tectonics have been studied in detail and the observations have been correlated to understand the earthquake phenomenon in the region. The morphotectonic behaviour of northern Bangladesh shows that it is deeply related to the movement of the Dauki fault system and relative upliftment of the Shillong plateau. Contemporary seismicity in the Dauki fault system is relatively quiet comparing to that in the Naga-Disang-Haflong thrust belt giving rise to the probability of sudden release of energy being accumulated in the vicinity of the Dauki fault system. This observation corresponds with the predicted average return period of a large earthquake (1897 type) and the possibility of M > 8 earthquake in the vicinity of the Dauki fault within this century should not be ruled out. The seismicity in the folded belt in the east follows the general trend of Arakan-Yoma anticlinorium and represents shallow and low-angled thrust movements in conformity with the field observation. Seismotectonic behaviour in the deep basin part of Bangladesh demonstrates that an intraplate movement in the basement rock has been taking place along the deep-seated faults causing relative upliftment and subsidence in the basin. Bangladesh has been divided into three seismic zones on the basis of morphotectonic and seismic behaviour. Zone-I has been identified as the zone of high seismic risk. (author). 43 refs, 5 figs, 3 tabs.

8610 (LBL–27879) **Fluid flow in fractured rock: Theory and application.** Long, J.C.S.; Hestir, K.; Karasaki, K.; Davey, A.; Peterson, J.; Kemeny, J.; Landsfeld, M. Lawrence Berkeley Lab., CA (USA). Jul 1989. 37p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00098. (CONF-8907175–1: NATO advanced study institute on transport processes in porous media, Pullman, WA (USA), 9-18 Jul 1989). Order Number DE90003938. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The phenomena of fluid flow in fractured rock is dominated by the fact that is not all parts of the domain are in hydraulic communication. In theory, it is possible to determine connectivity and permeability from stochastic parameters that describe the fracture geometry. When this approach is applied to the field we find it very difficult to sufficiently determine the geometry which controls the flow. Simulated annealing, an inverse technique which focus on finding the pattern of conductors may provide a better way to characterize these systems. 30 refs., 20 figs., 6 tabs.

8611 (SKB-TR–89-03) **Characterization of the morphology, basement rock and tectonics in Sweden.** Roeshoff, K. Swedish Nuclear Fuel and Waste Management Co., Stockholm (Sweden). 26 Aug 1988. 51p. Order Number DE90728327. Available from NTIS (US Sales Only), PC A04/MF A01.

The report is a compilation of the knowledge of the morphology, the bedrock geology and the tectonics of Sweden. The compilation is mainly based on published articles and maps. The result is presented on seven maps. 15 refs.

8612 (STF–60A89052) **Environmental conditions on the Norwegian continental shelf Barents sea.** Bjerke, P.L.; Torsethaugen, K. Norsk Hydroteknisk Lab., Trondheim (Norway). May 1989. 290p. Order Number DE90728265. Available from NTIS (US Sales Only), PC A13/MF A01.

Environmental data from the Barents Sea are presented. These data include data from measurements of waves, wind, current, water level and temperature, hindcast data for waves and wind and information on sea ice and icing. The data are synthesized for use in design and operational planning. An overview of the instrumentation used and rutine data analysis performed is given. Mathematical and statistical methods are used in the data analysis and presentation are discussed. 81 refs., 120 figs., 50 tabs. (Author).

8613 (STF–60A89077) **Wave factor for the Draugen field.** Torsethaugen, K. Norsk Hydroteknisk Lab., Trondheim (Norway). Aug 1989. 13p. (In Norwegian). Order Number DE90728266. Available from NTIS (US Sales Only), PC A03/MF A01.

An analysis has been made of wave data from station I1, position 65 degrees 05 minutes N, 7 degrees 34 minutes E, and from the Draugen field, position 64 degrees 17 min N, 7 degrees 45 minutes E on Haltenbanken. The ratio between the heights of a single wave and the significant wave with return period of 100 years, has been found to be 1.86. 4 refs., 3 figs. (OH).

8614 **Derivation of the complete Gutenberg-Richter magnitude-frequency relation using the principle of scale invariance.** Rundle, J.B. (Sandia National Laboratories, Albuquerque, New Mexico (US)). *Journal of Geophysical Research (USA),* 94(B9): 12337-12342 (10 Sep 1989).

The purpose of this paper is to show that the various observational parameters characterizing the statistical properties of earthquakes can be related to each other. The fundamental postulate which is used to obtain quantitative results is the idea that the physics of earthquake occurrence scales as a power law, similar to properties one often sees in critical phenomena. When the physics of earthquake occurrence is exactly scale invariant, b=1, and it can

be shown as a consequence that earthquakes in any magnitude band Δm cover the same area in unit time. This result therefore implies the existence of a "universal" covering interval τ_T, which is here called the "cycle interval." Using this idea, the complete Gutenberg-Richter relation is derived in terms of the fault area S_T, which is available to events of any given size, the average stress drop $\Delta\sigma_T$ for events occurring on S_T, the interval τ_T for events of stress drop $\Delta\sigma_T$ to cover an area S_T, and the scaling exponent α, which is proportional to the *b* value. Observationally, the average recurrence time interval for great earthquakes, or perhaps equivalently, the recurrence interval for characteristic earthquakes on a fault segment, is a measure of the cycle interval τ_T. The exponent α may depend on time, but scale invariance (self similarity) demands that α=1. It is shown in the appendix that the *A* value in the Gutenberg-Richter relation can be written in terms of S_T, τ_T, $\Delta\sigma_T$, and the parameter α. The *b* value is either 1 or 1.5 (depending on the geometry of the fault zone) multiplied by α. © American Geophysical Union 1989

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Refer also to citation(s) 8271, 8276, 8277, 8338, 8739, 8764, 8823

8615 (DOE/ER/40039–33) **Simultaneous observation of extensive air showers and underground muons at the Gran Sasso Laboratory.** MACRO Collaboration; EAS-TOP Collaboration. Texas A and M Univ., College Station, TX (USA). Dept. of Physics. [1989]. 5p. Sponsored by U.S. DOE Energy Research. DOE Contract AS05-81ER40039. (CONF-891260–2: International cosmic ray conference, Adelaide (Australia), 28 Dec 1989). Order Number DE90003241. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

In this paper we present new combined data from the MACRO underground detector located at the Gran Sasso Laboratory and the EAS-TOP surface array located on top of the mountain above MACRO at a zenith angle of 27.5° and separated by 3100 meters water equivalent (mwe) of rock. Discussed are the method of the event correlation and the characteristics of the reconstructed events. 4 refs., 3 figs.

8616 (DOE/ER/40039–34) **A search for magnetic monopoles with the MACRO detector at Gran Sasso.** MACRO Collaboration. Texas A and M Univ., College Station, TX (USA). Dept. of Physics. [1989]. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract AS05-81ER40039. (CONF-891260–3: International cosmic ray conference, Adelaide (Australia), 28 Dec 1989). Order Number DE90003240. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

The first supermodule of the MACRO detector with an acceptance for isotropic particle fluxes of about 800 m^2sr acquired ~80 days of data using specialized monopole triggers during February–May, 1989. With no monopole-like events observed, we report an upper limit on the monopole flux of 4×10^{-14} $cm^{-2}sr^{-1}s^{-1}$ (90% CL) for a monopole velocity range of $2.5 \times 10^{-4}c$ to $1.5 \times 10^{-2}c$. These results represent more stringent monopole flux limits at lower monopole velocities than reported by previous experiments. 4 refs., 2 figs.

8617 (DOE/ER/40039–36) **Multiple muon physics with the MACRO detector at Gran Sasso.** MACRO Collaboration. Texas A and M Univ., College Station, TX (USA). Dept. of Physics. [1989]. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract AS05-81ER40039. (CONF-891260–5: International cosmic ray conference, Adelaide (Australia), 28 Dec 1989). Order Number DE90003238. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

The first supermodule of the MACRO detector at the Gran Sasso Laboratory has been operating since the end of February 1989. About 245,000 muon triggers have been collected in the first three months of data taking corresponding to ~1890 hours of live-time. Presented here are the measured vertical muon flux as well as the lateral spread and multiplicity distribution of muon bundles. 4 refs., 5 figs.

8618 (DOE/ER/40039–37) **Study of the primary cosmic rays at $E_0 = 10^{13} - 10^{16}$ eV by simultaneous observation of extensive air showers and underground muons at the Gran Sasso Laboratory.** EAS-TOP Collaboration; MACRO Collaboration. Texas A and M Univ., College Station, TX (USA). Dept. of Physics. [1989]. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract AS05-81ER40039. (CONF-891260–6: International cosmic ray conference, Adelaide (Australia), 28 Dec 1989). Order Number DE90003237. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Combined measurements of Extensive Air Showers at the surface and deep underground muons are being performed at the Gran Sasso Laboratory by the EAS-TOP and MACRO detectors. We present a preliminary correlation of the measured parameters and discuss the future possibilities of the combined analysis. 4 refs., 6 figs.

8619 (DOE/ER/40039–38) **Search for stellar collapse with the MACRO detector at Gran Sasso.** MACRO Collaboration. Texas A and M Univ., College Station, TX (USA). Dept. of Physics; California Inst. of Tech., Pasadena, CA (USA). Dept. of Physics. [1989]. 5p. Sponsored by U.S. DOE Energy Research. DOE Contract AS05-81ER40039. (CONF-891260–7: International cosmic ray conference, Adelaide (Australia), 28 Dec 1989). Order Number DE90003236. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

The first MACRO supermodule commenced data taking in February 1989. Two complementary trigger and readout systems have been used to monitor the horizontal scintillation counters, which contain 42 tonnes (~1 ktonne for the full MACRO detector) of liquid scintillator, for bursts of low energy anti-neutrinos from gravitational stellar collapses. This paper reports on an initial search and discusses the present as well as ultimate sensitivity of MACRO to this class of events. 4 figs.

8620 (DOE/ER/40039–39) **The track-etch detector for the MACRO experiment at the Gran Sasso Laboratory.** MACRO Collaboration. Texas A and M Univ., College Station, TX (USA). Dept. of Physics. [1989]. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract AS05-81ER40039. (CONF-891260–8: International cosmic ray conference, Adelaide (Australia), 28 Dec 1989). Order Number DE90003235. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

The MACRO detector uses three complementary techniques for particle detection: liquid scintillation counters, limited streamer tubes, and track-etch plastics. In this paper the track-etch detector is described. Discussed are the track-etch implementation for the first supermodule; tests in progress on CR39 exposed to high energy ions; and the sensitivity of the track-etch system to GUT magnetic monopoles. 4 refs., 4 figs.

8621 (INIS-mf–11571) **11. European cosmic ray symposium: Invited talks.** Hungarian Academy of Sciences, Budapest (Hungary). Central Research Inst. for Physics. Mar 1989. 176p. (CONF-8808279–: 11. European cosmic ray symposium, Balatonfuered (Hungary), 21-27 Aug 1988). Order Number DE90611419. Available from NTIS (US Sales Only), PC A09/MF A01 - OSTI; INIS.

The biannual Symposium includes all aspects of cosmic ray research. The scientific programme was organized under three main headings: Cosmic rays in the heliosphere, Cosmic rays in the interstellar and extragalactic space, Properties of high-energy interactions as studied by cosmic rays. Seven invited talks were indexed seprately for the INIS database. (R.P.).

8622 (INIS-mf–11572) **11. European cosmic ray symposium held at Balatonfuered, Hungary, August 21-27, 1988: Abstracts.** Hungarian Academy of Sciences, Budapest (Hungary). Central Research Inst. for Physics. Aug 1988. 74p. (CONF-8808279–: 11. European cosmic ray symposium, Balatonfuered (Hungary), 21-27 Aug 1988). Order Number DE90611424. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

The biannual Symposium includes all aspects of cosmic ray research. The scientific programme was organized under three main

headings: Cosmic rays in the heliosphere, Cosmic rays in the interstellar and extragalactic space, Properties of high-energy interactions as studied by cosmic rays. Selected short communications out of 114 contributed papers were indexed separately for the INIS database. (R.P.).

8623 (LA-UR--89-2971) **A low threshold EAS [extensive-air-shower] array for gamma-ray astronomy at Los Alamos.** Burman, R.L. (Los Alamos National Lab., NM (USA)); Hoffman, C.M.; Nagle, D.E.; Potter, M.E.; Sandberg, V.; Berley, D.; Dingus, B.L.; Goodman, J.A.; Haines, T.J.; Stark, M.; Ellsworth, R.W.; Alexandreas, D.E.; Biller, S.; Dion, G.; Lu, X.Q.; Vishwanath, P.Los Alamos National Lab., NM (USA). 1990. 6p. Sponsored by U.S. DOE Energy Research. DOE Contract W-7405-ENG-36. (CONF-900122--1: 21. international cosmic ray conference, Adalaide (Australia), 6-19 Jan 1990). Order Number DE89016780. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

A new type of extensive-air-shower (EAS) array is described that achieves a low energy threshold, large area, high duty factor and large muon coverage. By placing a regularly-spaced grid of phototubes just below the surface of a shallow pond, the Cherenkov light of particles in an air shower striking the water can be detected, resulting in a primary energy threshold of less than 1 TeV. This highly sensitive array can thus be used to span the gap of information between the existing air Cherenkov techniques at 1 TeV and the existing EAS arrays at 100 TeV. 5 refs., 3 figs.

8624 (LA-UR--89-2989) **Relative muon content of UHE showers associated with Hercules X-1.** Alexandreas, D.E. (California Univ., Irvine, CA (USA)); Allen, R.C.; Biller, S.; Dion, G.; Lu, X-Q; Vishwanath, P.R.; Yodh, G.B.; Ellsworth, R.W.; Burman, R.L.; Cady, D.R.; Hoffman, C.M.; Lloyd-Evans, J.; Nagle, D.E.; Potter, M.E.; Sandberg, V.; WilkinsonLos Alamos National Lab., NM (USA). [1989]. 5p. Sponsored by U.S. DOE Energy Research. DOE Contract W-7405-ENG-36. (CONF-900122--3: 21. international cosmic ray conference, Adalaide (Australia), 6-19 Jan 1990). Order Number DE90000609. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

A further analysis is presented of the muon content associated with the July, 1986 UHE observation of the Hercules X-1 system, previously reported by the CYGNUS collaboration. The probability for observing comparable muon content in a set of "background" showers similar to those of the Hercules burst is given. 3 refs., 2 tabs.

8625 (LA-UR--89-3788) **A simple model for the stellar analogy of compact solar flares.** Kopp, R.A. (Los Alamos National Lab., NM (USA)); Poletto, G. Los Alamos National Lab., NM (USA). 1989. 4p. Sponsored by U.S. DOE Management & Administration. DOE Contract W-7405-ENG-36. (CONF-8909276--1: 6. Cambridge workshop on cool stars, stellar systems and the sun, Seattle, WA (USA), 11-14 Sep 1989). Order Number DE90003215. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

We have developed a simple "point" model to describe the average thermodynamical properties of a compact flare loop as a function of time during the flare decay phase. The model includes thermal conduction, chromospheric evaporation, and radiative losses; moreover, it assumes lateral (gas + magnetic) pressure balance with the background corona at all times. For the case of a low-β plasma (rigid flux tube), detailed 1-D hydrodynamical simulations are available in the literature for comparison; we show that the temporal variation of average loop properties predicted by the point model are in good agreement with these numerical simulations for a loop with the same energy input. 1 ref., 1 fig.

8626 (LA-UR--89-3982) **Large scale calculations of the structure and dynamics of dense matter.** Younger, S.M. Los Alamos National Lab., NM (USA). 1989. 12p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-36. (CONF-891052--1: Atomic processes in plasmas, Gaithersburg, MD (USA), 2-6 Oct 1989). Order Number DE90003654. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The physics of matter at high density has been found to be strongly influenced by transient quasi-molecular phenomena, the distribution of electron charge density among several nearby atoms. Calculations performed using the self-consistent field molecular dynamics approximation, a synthesis of techniques derived from quantum chemistry and molecular dynamics, have shown that such effects can result in more than a 30% increase in the diffusion coefficient of helium at 1 g/cc. The effect of finite electron temperature is to weaken many-electron collective phenomena, but significant effects are expected to occur even in fully ionized dense plasmas. 10 refs., 6 figs.

8627 (LBL--27673) **Cosmic ray half life of ^{56}Ni.** Norman, E.B.; Sur, B.; Lesko, K.T.; Larimer, R.M.; Browne, E. Lawrence Berkeley Lab., CA (USA). Aug 1989. 3p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00098. (CONF-900129--2: 21. international cosmic ray conference, Adelaide (Australia), 6-19 Jan 1990). Order Number DE90000132. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

A search for the β+ decay of ^{56}Ni has established an upper limit on the branching ratio of 7.2×10^{-7} for the most likely such transition. This provides a lower limit of 2.3×10^{4} years for the cosmic ray half life of ^{56}Ni. 2 refs., 2 figs.

8628 (RAL--89-069) **Perfect wetting: an alternative for hadronic matter formation in the cooling universe.** Frei, Z. (Eoetvoes Univ., Budapest (Hungary). Dept. of Atomic Physics); Patkos, A.;. Rutherford Appleton Lab., Chilton (UK). Jul 1989. 10p. Order Number DE90611415. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS.

Perfect wetting is proposed as a competitive mechanism for transforming the quark plasma phase into hadronic matter. (author).

8629 (RRK--89-19) **Cosmological observations in an inhomogeneous universe: Distance-redshift relation.** Watanabe, Kazuya; Tomita, Kenji. Hiroshima Univ., Takehara (Japan). Research Inst. for Theoretical Physics. Jun 1989. 30p. Order Number DE90733096. Available from NTIS (US Sales Only), PC A03/MF A01.

The distance-redshift relation in an inhomogeneous universe is studied. On the basis of relativistic optical equations, numerical calculations are performed to get a realistic distance-redshift relation. It is shown that the distance-redshift relation is coincident with that in the standard Friedmann-Robertson-Walker (FRW) model on average if galaxies or clusters of galaxies are assumed to be completely transparent. We also show that the effect of shear along the light path is small if the scale of inhomogeneities is larger than galactic scale and that our numerical results are consistent with the analytical investigation recently done by Futamase and Sasaki. (author).

8630 (UCRL--101851) **Turbulent stripping of interstellar clouds by interaction with supernova remnants.** Klein, R.I. (Lawrence Livermore National Lab., CA (USA)); McKee, C.F.; Colella, P. Lawrence Livermore National Lab., CA (USA). 8 Sep 1989. 21p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. (CONF-8906257--1: 1989 centennial meeting of the American Astronomical Society of the Pacific, Berkeley, CA (USA), 21-23 Jun 1989). Order Number DE90003622. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

We present results for the interaction of a supernovae remnant blast wave with a small interstellar cloud, using for the first time high resolution local adaptive mesh refinement techniques with an underlying second order accurate 2-D Godunov hydrodynamic scheme. The cloud shock is assumed to be strong enough that it is non-radiative. We follow the morphological evolution of the cloud in great detail as it undergoes a series of complex shock-shock interactions and Kelvin-Helmholtz and Rayleigh-Taylor instabilities. We demonstrate, over a large range of cloud densities and shock strengths, that clouds are efficiently destroyed in a few cloud crushing times (essentially, the Rayleigh Taylor time) by a combination of instabilities and large scale shear flow. We investigate the scaling properties of clouds of different densities and shocks of different strengths. Our results have uncovered the development of copious supersonic vortex rings produced in the shear flow layer of the interaction. These vortex rings may wrap up ambient magnetic fields, enhancing the synchrotron emission and possibly explaining the compact radio hot spots seen in Cas A. Our calculations have, for the first time, carried the cloud-shock interaction well into the fragmentation regime. We demonstrate that similar calculations with

standard fixed grid hydrodynamic schemes would require one to two orders of magnitude more computational time than is needed with our adaptive mesh approach to achieve comparable results. 20 refs., 114 figs., 1 tab.

8631 (UCRL–101948) **Thermal pair cloud models of MeV gamma ray emissions from Cygnus X-1 and the Galactic Center.** Liang, E.P. (Lawrence Livermore National Lab., CA (USA)); Dermer, C.D. Lawrence Livermore National Lab., CA (USA). 12 Sep 1989. 4p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. (CONF-900122–4: 21. international cosmic ray conference, Adalaide (Australia), 6-19 Jan 1990). Order Number DE90001169. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The HEAO-3 data for the enhanced MeV gamma ray emissions of Cygnus X-1 and the Galactic Center in 1979 can be modeled by thermal emissions from a compact pair-dominated cloud surrounding the black hole. We derive from first principles the structure of such pair clouds and use these results to constrain the mass of the central black hole, the viscosity parameter and other parameters of the innermost accretion flow. We estimate the production and escape of pairs outside the thermal cloud due to collisions of gamma rays with other gamma rays and with x-rays from the disk. The annihilation of such escaped pairs in the cool medium far from the source can lead to detectable narrow 511 keV lines. These results are compared with the variable 511 keV source in the Galactic Center and the upper limits for Cygnus X-1. 12 refs., 2 figs.

8632 (UCRL–102003) **Detailed non-LTE calculations of the iron emission from NGC 1068.** Band, D.L.; Klein, R.I.; Castor, J.I.; Nash, J.K. Lawrence Livermore National Lab., CA (USA). 1989. 22p. Sponsored by U.S. DOE Defense Programs; National Aeronautics and Space Administration. DOE Contract W-7405-ENG-48. (CONF-8909275–2: 23. ESLAB symposium on X-ray astronomy, Bologna (Italy), 13-20 Sep 1989; ESA-SP–296). Order Number DE90003617. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

We model the x-ray iron line emission from NGC 1068 observed by the Ginga satellite using the new multi-line, multi-level, non-LTE radiative transport code ALTAIR and a detailed atomic model for Ne-like through stripped iron. With these detailed calculations we study the parameter space of the "obscured type 1 Seyfert nucleus" model for this object. We find that the equivalent width is greater than previously predicted because the observed Kα line is produced not only by fluorescence but also by scattering of the continuum into our line of sight by the line opacity. We find that detailed radiative transfer can have a significant effect on the observed line flux both for the Kα line and for the L-shell emission. The ionization of the iron increases with temperature. Therefore the Kα equivalent width and energy is a function not only of the ionization parameter, but also of the column depth and temperature. For a likely model of NGG 1068 we find that the iron abundance is about twice solar, but that modifications of this model may permit a smaller abundance. 17 refs., 6 figs.

8633 (UCRL–102181) **Nuclear reaction uncertainties in standard and non-standard cosmologies.** Malaney, R.A. Lawrence Livermore National Lab., CA (USA). 6 Oct 1989. 14p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. (CONF-8910320–1: Workshop on primordial nucleosynthesis, Chapel Hill, NC (USA), 6-8 Oct 1989). Order Number DE90003594. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

We discuss here the uncertainties in the nuclear input data relevant for calculations of standard and non-standard primordial nucleosynthesis. We show how these uncertainties can affect the predictive power of such calculations, and we identify those key nuclear reactions for which improved experimental data on the associated reaction rates is most needed. Such experimental data can lead to more accurate discriminatory tests between the differing primordial nucleosynthesis scenarios. 34 refs., 3 tabs.

8634 (UCRL–102238) **Ion-heated thermal Comptonization models and x-ray spectral correlations in active galactic nuclei.** Dermer, C.D. Lawrence Livermore National Lab., CA (USA). Nov 1989. 7p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. (CONF-8909275–1: 23. ESLAB symposium on X-ray astronomy, Bologna (Italy), 13-20 Sep 1989). Order Number DE90003597. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Recent Ginga observations of the Seyfert 1 galaxies NGC 4051 and MCG 6-30-15 show a positive correlation between the 2-10 keV luminosity and photon spectral index α. Similar behavior has also been reported in Exosat and Einstein observations of other active galactic nuclei, and is suggested in hard x-ray low-state data of the galactic black-hole candidate Cygnus X-1. A two-temperature thermal Comptonization model with internal soft-photon production provides a simple explanation for this correlation. The electron temperature, determined by a balance between ion heating and radiative cooling, decreases in response to an enhancement of the soft photon flux, resulting in a softening of the spectrum and an increase in the soft x-ray luminosity. The bulk of the soft photons are produced through pion production in collisions between the hot ions. Pivoting of the spectrum at photon energies $\varepsilon > 50$ keV is a consequence of variations in the ion temperature. An important test of the model would be time correlations between soft and hard x-ray bands. 17 refs., 9 figs., 1 tab.

8635 (UCRL–102240) **The excess flux in the cosmic submillimeter background radiation and the primordial deuterium abundance.** Dermer, C.D. (Lawrence Livermore National Lab., CA (USA)); Guessoum, N. Lawrence Livermore National Lab., CA (USA). 27 Oct 1989. 6p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. (CONF-900129–3: 21. international cosmic ray conference, Adelaide (Australia), 6-19 Jan 1990). Order Number DE90003602. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Recent measurements of the cosmic background radiation (CBR) show an enhanced flux in the submillimeter regime, compared to the spectrum of a 2.7 K blackbody. Thermal Comptonization of the relic radiation by a hot nonrelativistic plasma has long been known to produce distortions in the CBR spectrum, similar to what has now been observed. Heating of the primeval plasma to temperatures T $\sim 10^6 - 10^8$ K could result from the injection of subcosmic ray protons at epoch z $\sim$ 10–100. The intensity of the subcosmic ray flux that provide conditions needed to explain the submillimeter excess by thermal Comptonization also leads to the production of cosmologically significant amounts of deuterium in collisions between subcosmic ray protons and primordial protons and α-particles. However, the amount of lithium produced through α-α reactions is in conflict with the observed Li abundance. If lithium is depleted, for example, by processing through Population II stars, arguments for the baryon content of the universe based on primordial deuterium and He abundances are weakened. 12 refs., 1 fig., 1 tab.

8636 (UCRL–102243) **Use of the Egret instrument in studies of the origin of the cosmic radiation: 2., Spectral signatures of discrete cosmic-ray sources.** Dermer, C.D. Lawrence Livermore National Lab., CA (USA). 27 Oct 1989. 6p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. (CONF-900129–4: 21. international cosmic ray conference, Adelaide (Australia), 6-19 Jan 1990). Order Number DE90003595. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

This is a continuation of previous studies aimed at predicting spectral signatures of discrete cosmic-ray sources. In this paper, a formalism is developed for calculating gamma-ray spectra observed at Earth from the decay of neutral pions formed in collisions of cosmic-ray protons and ions with galactic gas and dust. The cosmic rays are assumed to be emitted by discrete sources, and their intensities and spectra are described by solutions to a diffusion equation. Calculations of spectral signatures expected from these hypothetical point sources of cosmic rays are presented. In particular, a steady source of cosmic rays could show a harder gamma-ray spectrum than the spectrum of the diffuse galactic background, whereas an impulsive source of cosmic rays could show a much softer spectrum. Observations of the angular variations of gamma-ray intensities and spectra near point sources will provide information on cosmic-ray propagation in other parts of our galaxy, as well as on the nature of the discrete sources themselves. Capabilities of the Egret telescope in mapping spectra from cosmic-ray point sources are briefly discussed. 14 refs., 2 figs.

8637 Cosmic microwave background distortions at high frequencies. Peter, W. (Los Alamos National Lab. (US)); Peratt, A.L. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4P49.

The authors analyze the deviation of the cosmic background radiation spectrum from the 2.76+-0.02^{0}K blackbody curve. If the cosmic background radiation is due to absorption and re-emission of synchrotron radiation from galactic-width current filaments, higher-order synchrotron modes are less thermalized than lower-order modes, causing a distortion of the blackbody curve at higher frequencies. New observations of the microwave background spectrum at short wavelengths should provide an indication of the number of synchrotron modes thermalized in this process. The deviation of the spectrum from that of a perfect blackbody can thus be correlated with astronomical observations such as filament temperatures and electron energies. The results are discussed and compared with the theoretical predictions of other models which assume the presence of intergalactic superconducting cosmic strings.

8638 Pulsations of white dwarf stars with thick hydrogen or helium surface layers. Cox, A.N. (Los Alamos National Lab., Los Alamos, NM (US)). pp. 422 of Stellar pulsation. Cox, A.N. Sparks, W.M. Starrfield, S.G Springer-Verlag New York Inc., New York, NY (1987). (CONF-8608130–: Stellar pulsation conference, Los Alamos, NM (USA), 11-15 Aug 1986).

In order to see if there could be agreement between results of stellar evolution theory and those of nonradial pulsation theory, calculations of white dwarf models have been made for hydrogen surface masses of $10^{-4}M_{solar}$. Earlier results indicated that surface masses greater than $10^{-8}M_{solar}$ would not allow nonradial pulsations, even though all the driving and damping is in surface layers only 10^{-12} of the mass thick. The authors show that the surface mass of hydrogen in the pulsating white dwarfs (ZZ Ceti variables) can be any value as long as it is thick enough to contain the surface convection zone. They show the growth rates for pulsation modes at the blue edge of the instability strip for, respectively, 10^{-4} and $10^{-8}M_{solar}$ layers of hydrogen at the surface. One can see that in both cases the growth rates generally increase with period (with g mode order) up to the longest unstable period, and they range from 10^{-5} to 10^{-1} per period. This independence of the pulsation upon hydrogen layer thickness agrees with the observed fact that apparently all the white dwarfs that are in the instability strip are pulsating in one or more nonradial modes. If only the thin layer ones were unstable, then a thick hydrogen shell white dwarf would be stable. There would then be some nonpulsating white dwarfs in the ZZ Ceti instability strip.

8639 Products from cosmic-ray interactions in extraterrestrial matter: What they tell us about radiation backgrounds in space. Reedy, R.C. (Los Alamos National Laboratory, Los Alamos, NM 87545 (US));. *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 186(1): 97-102 (15 May 1989). (CONF-8711149–: Conference on high energy radiation background in space, Sanibel Island, FL (USA), 2-5 Nov 1987).

The nuclides and the heavy-nuclei "tracks" made by the interactions of solar and galactic cosmic-ray particles with meteorites, lunar samples, and the Earth have been extensively studied, simulated, and modelled. Most research involves the use of these cosmogenic products to study the history of the "targets" or of the cosmic rays. However, much work has also been done in understanding these interactions and in predicting their rates as a function of the target's size and shape and of the location inside the target. These studies apply to any object exposed to cosmic rays. The fluxes as a function of depth for cosmic-ray primary and secondary particles vary greatly with particle energy and type. The variations of the fluxes of these cosmic rays in the past have been studied. Energetic solar particles are unpredictable and are the greatest potential radiation hazard in space.

8640 Bremsstrahlung production by electrons: Cross sections and electron-photon transport calculations. Seltzer, S.M. (National Bureau of Standards, Gaithersburg, MD 20899 USA (US));. *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 186(1): 103-124 (15 May 1989). (CONF-8711149–: Conference on high energy radiation background in space, Sanibel Island, FL (USA), 2-5 Nov 1987).

This paper describes the rather accurate Monte Carlo model and cross sections that have been used to calculate effects from electrons and photons on measurement, electronic and biological systems in space. A number of applications are illustrated, with emphasis on effects from bremsstrahlung produced by electrons.

8641 The interaction of supernovae with circumstellar bubbles. Chevalier, R.A. (Virginia Univ., Charlottesville (USA)); Liang, E.P. *Astrophysical Journal (USA),* 344: 332-340 (Sep 1989).

This paper examines the interaction of a massive star supernova with the shell created by the fast wind from a blue supergiant, either in the main-sequence phase or in a late evolutionary phase. Making a number of idealizations, the general features of shell interaction are described by semianalytical solutions. The expected properties of the supernova and its environment are discussed, and the hydrodynamics of the interaction is described. It is found that, typically, the shock traversal occurs before the energy transfer is significant. Applications of the model to observed objects are considered, with special attention given to the interaction of SN 1987A with its circumstellar shell, which is expected to occur within decades. 56 refs.

8642 A coasting cosmology. Kolb, E.W. (NASA/Fermi National Accelerator Laboratory, Batavia, IL (USA)). *Astrophysical Journal (USA),* 344: 543-550 (Sep 1989).

A Friedmann-Robertson-Walker cosmology with energy density decreasing in expansion as 1/R-squared, where R is the Robertson-Walker scale factor, is studied. In such a model the universe expands with constant velocity; hence the term coasting cosmology. Observational consequences of such a model include the age of the universe, the luminosity distance-redshift relation (the Hubble diagram), the angular diameter distance-redshift relation, and the galaxy number count as a function of redshift. These observations are used to limit the parameters of the model. Among the interesting consequences of the model are the possibility of an ever-expanding closed universe, a model universe with multiple images at different redshifts of the same object, a universe with Omega - 1 not equal to 0 stable in expansion, and a closed universe with radius smaller than 1/H(0). 8 refs.

8643 Three-dimensional hydrodynamical simulations of stellar collisions. II. White dwarfs. Benz, W. (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA (USA)); Thielemann, F.K.; Hills, J.G. *Astrophysical Journal (USA),* 342: 986-998 (Jul 1989).

Three-dimensional numerical simulations are presented for collisions between white dwarfs, using a smooth-particle hydrodynamics code with 5000 particles. The code allows for radiation and degenerate pressure and uses a reduced nuclear network which models the large release of nuclear energy. Two different collision models are considered over a range of impact parameters: between two 0.06 solar-mass C-O white dwarfs and between 0.9 solar-mass and 0.7 solar-mass C-O white dwarfs. In nearly head-on collisions, a very substantial fraction of the mass is lost as a result of a large release of nuclear energy. In grazing collisions, the fraction of mass lost is close to that produced in collisions between main-sequence stars. The quantity of processed elements ejected into the ISM by these collisions does not significantly affect the chemical evolution of the Galaxy. 24 refs.

8644 Close encounters between star-planet systems and stellar intruders. II. Effect of the mass and impact velocity of the intruder. Hills, J.G. (Los Alamos National Laboratory, NM (USA)); Dissly, R.W. *Astronomical Journal (USA),* 98: 1069-1082 (Sep 1989).

Results are reported from over 300,000 simulations of encounters between a planet-star binary system and intruders whose masses range from 0.1 to 100 times the mass of the home star of the planet-star system. These calculations were done at a large number of collision velocities and impact parameters. Cross sections for dissociation, for exchange collisions, for changing the orbital energy, and for changing the orbital eccentricity were determined. 16 refs.

8645 Cyclic appearances and disappearances of pulsars: Application to pulsar in SN 1987A. Glendenning, N.K. (Nuclear Science Division, Lawrence Berkeley Laboratory, 1 Cyclotron Road, Berkeley, California 94720 (US));. *Physical Review Letters (USA)*, 63(14): 1443-1446 (2 Oct 1989). DOE Contract AC03-76SF00098.

It is shown that a very small asymmetric ellipicity of the pulsar discovered in SN 1987A could cause cyclic appearance and disappearance of the signals due to the slow rotation about the body symmetry axis which could carry the magnetic axis out of our line of sight. Taking account of gravitational-radiation damping, eccentricities that are consistent with the measured small rate of change of the millisecond period would yield a period for the disappearances ranging from about an hour to the age of the Universe. We also examine precession as a possible explanation of the observed eight-hour modulation of the millisecond pulses. While a sinusoidal frequency modulation of the correct period can be found, the amplitude of the modulation is much too small compared to observation.

8646 Cyclotron resonant scattering in the spectra of γ-ray bursts. Wang, J.C.L. (Department of Astronomy and Astrophysics, University of Chicago, Chicago, IL 60637 (US)); Lamb, D.Q.; Loredo, T.J.; Wasserman, I.M.; Salpeter, E.E.; Fenimore, E.E.; Conner, J.P.; Epstein, R.I.; Klebesadel, R.W.; Laros, J.G.; Murakami, T.; Nis *Physical Review Letters (USA)*, 63(15): 1550-1553 (9 Oct 1989).

Fits of theoretical spectra from Monte Carlo radiation-transfer calculations to dips at $\approx$20 and 40 keV in a spectrum of the "classical" γ-ray burst GB 880 205 give best-fit values and 68%-confidence intervals $B=(1.71\pm0.07)\times10^{12}$ G, $N_e=(1.2\pm0.6)\times10^{21}$ electrons/cm^2, and $\mu=\cos\theta=0.31\pm0.05$, where θ is the viewing angle relative to the field. Physical self-consistent fixes the temperature at $T_C=5.3_{-0.2}^{+0.3}$ keV. These results suggest that this γ-ray burst and many others which exhibit a low-energy dip originate from strong magnetic neutron stars and are galactic in origin.

8647 Light propagation and the distance-redshift relation in a realistic inhomogeneous universe. Futamase, T. (Department of Physics, Faculty of Science, Hirosaki University, Hirosaki 036, Japan (JP)); Sasaki, M. *Physical Review [Section] D: Particles and Fields (USA)*, 40(8): 2502-2510 (15 Oct 1989).

We investigate the propagation of light rays in a clumpy universe constructed by a cosmological version of the post-Newtonian approximation. We show that the linear approximation to the propagation equations is valid in the region $z\lesssim1$ even if the density contrast is much larger than unity. Based on a general order-of-magnitude statistical consideration, we argue that the linear approximation is still valid for $z\gtrsim1$. Then we give a general formula for the distance-redshift relation in a clumpy universe and derive an explicit expression for a simplified situation in which the effect of the gravitational potential of inhomogeneities dominates. In the light of the derived relation we discuss the validity of the Dyer-Roeder distance. Furthermore, we consider a simple model of an inhomogeneous universe and investigate statistical properties of light rays. We find that the result of this specific example also supports the validity of the linear approximation.

8648 Initial-condition dependence of inflationary-universe models. Kung, J.H. (Physics Department, Brown University, Providence, Rhode Island 02912 (US)); Brandenberger, R. *Physical Review [Section] D: Particles and Fields (USA)*, 40(8): 2532-2541 (15 Oct 1989).

An analytical and numerical study of the effects of initial conditions on the evolution of a classical scalar field is presented. In this model, matter consists of a scalar field and a radiation bath. The initial energy density of the scalar field is taken to be equal to the energy density of one degree of freedom of the radiation bath. Even for this subspace of the space of initial conditions, three very different scenarios are possible. One may get chaotic inflation, dynamical relaxation, or a tension energy-dominated universe which results in no inflation. The phase space for each of these scenarios is determined.

8649 Angular momentum and the mass function of galaxies seeded by cosmic strings. Brandenberger, R.H. (Department of Physics, Brown University, Providence, Rhode Island 02912 (US)); Shellard, E.P.S. *Physical Review [Section] D: Particles and Fields (USA)*, 40(8): 2542-2548 (15 Oct 1989).

In the standard gravitational instability picture with cosmic strings, galaxies acquire angular momentum through tidal torquing by neighboring accretion sites. Given the quadrupole moment induced by loop peculiar velocities, we estimate the resulting angular momentum of large galaxies in the low-density field. In models with cold dark matter (CDM) we show that this source of angular momentum is sufficient to be compatible with observation, though for hot dark matter we uncover apparent difficulties, in the absence of other mechanisms. We also examine the mass function of field galaxies. In the CDM cosmic-string model, substantial evolution due to the merging of objects leads to a significant decrease in the slope of the initial mass function by the present time.

8650 Rate for annihilation of galactic dark matter into two photons. Giudice, G.F. (Fermi National Accelerator Laboratory, Batavia, Illinois 60510 (US)); Griest, K. *Physical Review [Section] D: Particles and Fields (USA)*, 40(8): 2549-2558 (15 Oct 1989).

We perform a calculation of the cross section for neutralino-neutralino annihilation into two photons and apply it to dark matter in the galactic halo to find the counting rate in a large γ-ray detector such as EGRET or ASTROGAM. Combining constraints from particle accelerators with the requirement that the neutralinos make up the dark matter we find that rates over a few dozen events per year are unlikely. We list the assumptions that go into our conclusions and suggest other particle dark-matter candidates which could give larger and perhaps observable signals.

8651 String distributions above the Hagedorn energy density. Deo, N. (Mount Holyoke College, South Hadley, Massachusetts 01075 (US)); Jain, S.; Tan, C. *Physical Review [Section] D: Particles and Fields (USA)*, 40(8): 2626-2635 (15 Oct 1989).

The formalism for discussing energy and charge distribution functions in the microcanonical ensemble is presented and applied to strings. This yields information of direct physical significance in string statistical mechanics. Above the Hagedorn energy density the free string gas exhibits a number of interesting features. For toroidal compactification, the distribution of the total energy among strings of various energies depends upon the number of noncompact spatial dimensions d. For $d=0$ the energy is distributed uniformly among strings at all energy scales, while for $d\geq3$ a single string captures most of the energy. The imposition of conservation laws does not alter this qualitative picture. We show that the $d=1$ and $d=2$ cases are qualitatively different from the others.

8652 Three-dimensional simulation of diamagnetic cavity formation by a finite-sized plasma beam. Thomas, V.A. (Applied Theoretical Physics Division, Los Alamos National Laboratory, Los Alamos, New Mexico (US));. *Journal of Geophysical Research (USA)*, 94(A10): 13579-13584 (1 Oct 1989).

The problem of collisionless coupling between a plasma beam and a background plasma is examined using a three-dimensional hybrid code. The beam is assumed to be moving parallel to an ambient magnetic field at a speed greater than the local Alfven speed. In addition, the beam has a finite spatial extent in the directions perpendicular to the magnetic field and is uniform and infinite in the direction parallel to the ambient magnetic field. Such a system is susceptible to coupling of the beam ions with the background ions via an electromagnetic ion beam instability. This instability isotropizes the beam and energizes the background plasma. A large-amplitude Alfven wave traveling radially away from the interaction region is associated with the energized background plasma. The process described here is one which may be responsible for the formation of diamagnetic cavities observed in the solar wind. © American Geophysical Union 1989

6402 Atmospheric Physics

Refer also to citation(s) 8876, 8977

8653 Nonlinear periodic surface waves on the Brillouin sheath. Robertson, J.A. (VARIAN ASSOCIATES, Varian Beverly Microwave Div., Beverly, MA (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4P33.

Propagation of large-amplitude surface waves on a uniform-density electron beam in planar crossed-field geometry is investigated numerically. Within the guiding-center approximation, the flow may be taken to be incompressible, and the state of the electron sheath is fully specified by the shape and topology of the plasma-vacuum interface. Periodic surface undulations which are stationary in some inertial frame are found, using a relaxation technique. Wave solutions are studied both in the presence and absence of conducting boundaries. The present analyses extend the well-known results for infinitesimal surface modulations far into the nonlinear regime. The amplitude dependence of the phase velocity is determined. Bifurcations in the permitted classes of stationary surface structures are observed to take place as the system parameters (e.g. sheath volume, wavelength) are varied. The total potential energy of the various sheath configurations is analyzed in order to address the question of the stability of the solutions.

8654 Wave propagation effects on broadband electrostatic ion beam instabilities in the magnetotail. Grabbe, C. (Dept. of Physics, Univ. of Iowa, Iowa City, IA (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4P48.

Recent papers have shown that broadband electrostatic noise spectrum is produced by three ion beam instabilities: the resistive beam-ion acoustic instability, the ion-ion two-stream instability, and the reactive ion-electron (Buneman) two-stream instability. However, the different characteristics of the three instabilities should show up as wave propagation effects, and provides a prediction as to how the spectrum should evolve as the spacecraft approaches the plasma sheet boundary layer from the lobe. The three instabilities appear at different times, giving a characteristic signature for certain times of crossing. Cases where this signature and variations on it occur are presented and discussed. This data may be very useful in verifying the theory.

6403 Atomic, Molecular, and Chemical Physics

Refer also to citation(s) 8030, 8105, 8151, 8828, 8858, 8860, 8931

8655 (BNL–43462) **Auger and x-ray absorption studies of solid molecular oxygen.** Chen, Jie (Brookhaven National Lab., Upton, NY (USA)); Lin, C.L.; Qui, S.L.; Strongin, M.; denBoer, M.L. Brookhaven National Lab., Upton, NY (USA). [1989]. 15p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-891093–16: 36. American Vacuum Society national vacuum symposium, Boston, MA (USA), 23-27 Oct 1989). Order Number DE90003966. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

We have studied the x-ray absorption spectrum (XAS) and the Auger electron spectrum (AES) of condensed molecular oxygen in the vicinity of the O 1s (K) core level. The XAS spectrum, which is similar to that previously reported for gas phase O_2, has sharp peaks at about 530.8 eV and 540.3 eV which we attribute to excitations from the 1s level into π^* and σ^* states respectively. We assign a third peak at 543.3 eV to Rydberg transitions. Compared with gas phase O_2, the σ^* and Rydberg states are shifted to higher energies, an effect which we attribute to solid state effects in the condensed layer. The AES spectra of the ionized molecule and excited molecule are both shifted relative to the spectra of gas phase O_2, but by different amounts, 10 eV and 2 eV respectively, which may be due to different final state screening effects. A tentative assignment of the features in the AES spectra is also made. 16 refs., 2 figs., 1 tab.

8656 (CONF-8908191–2) **Structure-property correlations in the design of organic metals and superconductors: An overview.** Kini, A.M.; Beno, M.A.; Carlson, K.D.; Ferraro, J.R.; Geiser, U.; Schultz, A.J.; Wang, H.H.; Williams, J.M. Argonne National Lab., IL (USA). [1989]. 8p. Sponsored by U.S. DOE Energy Research. DOE Contract W-31109-ENG-38. From 1. ISSP international symposium on the physics and chemistry of organic superconductors; Tokyo (Japan); 27-30 Aug 1989. Order Number DE90003794. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Molecular structure and, more importantly, molecular packing in organic superconducting salts $(TMTSF)_2X$, β-$(BEDT\text{-}TTF)_2X$ and κ-$(BEDT\text{-}TTF)_2X$ will be examined in the context of deducing structure-property correlations in these systems. Such an approach has been instrumental in the discovery of superconductivity at 10.4 K in κ-$(BEDT\text{-}TTF)_2Cu(NCS)_2$, and it will continue to serve as an important tool in the rational design of new organic superconductors with even higher superconducting transition temperatures.

8657 (INIS-mf–11519) **New directions in the theory of spin-polarized atomic hydrogen and deuterium.** Koelman, J.M.V.A. Technische Univ. Eindhoven (Netherlands). 13 Dec 1988. 124p. Order Number DE90705958. Available from NTIS (US Sales Only), PC A06/MF A01 - OSTI.

The three chapters of this thesis dealing with collisions between hydrogen (or deuterium) atoms in their ground state, each treat a different development in the theory of atomic hydrogen or deuterium gas. The decay due to interatomic collisions hindered till now all attempts to reach the low temperature, high-density regime where effects due to degeneracy are expected to show up. In chapter 2 a simple way out is presented for the case of Fermi gases: in spin-polarized Fermi systems at very low temperatures collisions are much more effective than in Bose systems. For the Fermi gas, consisting of magnetically confined deuterium atoms, it appears that fast spin-exchange collisions automatically lead to a completely spin-polarized gas for which the spin-relaxation limited lifetime increases dramatically with decreasing temperature. As also the ratio of internal thermalization rate over decay rate increases with decreasing temperature, this gas can be cooled by forced evaporation down to very low temperatures. In chapter 3 it is shown that the nuclear spin dynamics due to the hyperfine interaction during collisions, strongly limits the improvement in frequency stability attainable by H masers operating at low temperatures. In chapter 4 the phenomenon of spin waves is studied. It is shown that, despite the fact that interactions between two atoms are nuclear-spin independent, the outcome of a scattering event does not depend on the nuclear spins involved due to the particle indistinguishability effects at low collision energies. This effect gives rise to quantum phenomena on a macroscopic scale via the occurrence of spin waves. 185 refs., 34 figs.

8658 (INP–1318/PS) **Far infrared study of molecular reorientations in some alkoxyazoxybenzenes.** Godlewska, M. (Uniwersytet Jagiellonski, Cracow (Poland). Inst. Fizyki); Janik, J.A.; Nguyen, X.P.; Sciesinski, J.; Witko, W.; Kocot, A. Institute of Nuclear Physics, Cracow (Poland). May 1986. 19p. Order Number DE90610543. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

Far infrared spectra in the frequency range 20 - 200 cm^{-1} for di-n-alkoxyazoxybenzene homologous series are presented for the isotropic and nematic phases and for 0.1 M solution in benzene. Additionally some partly deuterated samples were measured. The spectra generally consist of two broad bands. By comparison of the spectra for differently deuterated compounds it was possible to interpret the higher frequency band as being connected with the intermolecular torsional vibration of the groups. We connect the band at lower frequencies with the Poley absorption of librating molecules. The confined rotator model calculations performed for this band for all compounds studied give the rotational correlation time which happens to be in good agreement with the correlation times as derived from the quasielastic neutron scattering experiments. 12 refs., 7 figs., 3 tabs. (author).

8659 (INS–753) **Trapping of negative kaons by metastable states during the atomic cascade in liquid helium.** Yamazaki, T.; Aoki, M.; Iwasaki, M.; Hayano, R.S.; Ishikawa, T.; Outa, H.; Takada, E.; Tamura, H.; Sakaguchi, A. Tokyo Univ., Tanashi (Japan). Inst. for Nuclear Study. Jun 1989. 12p. Order Number DE90733098. Available from NTIS (US Sales Only), PC A03/MF A01.

We observed two distinct peaks, 205 MeV/cpi$^-$ and 235 MeV/cmu$^-$, associated with K_{pi2}^- and K_{mu2}^- decays at rest, respectively, from negative kaons stopped in liquid helium. These peaks were found to be delayed with respect to the stopping K^-, showing that stopped K^- mesons of about 2% fraction are trapped in

metastable states with an overall lifetime of about 40 nsec. This observation provides a direct evidence for Condo's trapping hypothesis for the at-rest decay components of K^- and pi^- in liquid helium. (author).

8660 (Juel–1986) **Spectroscopic study of atomic beams generated by laser ablation of multi-layer targets.** Koppmann, R.; Refaei, S.M.; Pospieszczyk, A. Association Euratom-Kernforschungsanlage Juelich (Germany, F.R.). Inst. fuer Plasmaphysik. Mar 1985. 30p. Order Number DE90732694. Available from NTIS (US Sales Only), PC A03/MF A01.

An experiment is described where Li- and Al-beams were generated by ablation of thin, multi-layer targets using a Q-Switched ruby laser with a total energy density up to 30 Jcm^{-2}. Measurements using laser induced fluorescence and mass spectroscopy were combined to analyse the energy- and density distribution and the temporal structure of the beams. The maximum energy turned out to be several eV for Li and several 10 eV for Al with a peak density in the range of 10^{10} cm^{-3} for both Li and Al. The targets were analysed by optical microscopy and secondary ion mass spectroscopy providing information about the size of the spots and the structure of the metal film before and after the ablation experiment. (orig.).

8661 (LA-UR–89-3769) **Progress in LTE and non-LTE transport calculations.** Keady, J.J. (Los Alamos National Lab., NM (USA)); Huebner, W.F.; Abdallah, J. Jr.; Magee, N.H. Jr. Los Alamos National Lab., NM (USA). 1989. 15p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-36. (CONF-8905245–1: Advanced NATO research workshop: physical processes in hot cosmic plasmas, Sicily (Italy), May 1989). Order Number DE90003394. Available from NTIS, PC A03/MF A01 - OSTI.

The physical processes in ionized gases are reviewed along with recent calculations of particular processes. Ongoing opacity calculations at Los Alamos are described. Some of the open issues in the calculation of physical processes relevant to opacities are discussed. 39 refs., 7 figs.

8662 (LA-UR–89-4047) **Atomic processes in plasmas under ultra-intense laser irradiation.** Schappert, G.T.; Casperson, D.E.; Cobble, J.A.; Comly, J.C.; Jones, L.A.; Kyrala, G.A.; LaGattuta, K.J.; Lee, P.H.Y.; Olson, G.L.; Taylor, A.J. Los Alamos National Lab., NM (USA). Nov 1989. 16p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-36. (CONF-8911138–1: 7. American Physical Society topical conference on atomic processes in plasmas, Gaithersburg, MD (USA), Nov 1989). Order Number DE90003221. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Lasers delivering subpicosecond pulses with energies of a fraction of a Joule have made it possible to generate irradiance levels approaching 10^{20} W/cm^2. We presently operate two such systems, a KrF based excimer laser capable of producing a few 10^{17} W/cm^2 at 248 nm with a repetition rate of 3–5 Hz and a XeCl based excimer laser capable of producing mid 10^{19} W/cm^2 at 308 nm and 1 Hz. We will discuss some experimental results and the theory and modeling of the interaction of such intense laser pulses with aluminum. Because of a small ASE prepulse the high intensity interaction is not at the solid surface but rather at the $n_e = 2 \times 10^{22}$ cm^{-3} critical density of the blowoff plasma generated by the ASE. The transient behavior of the plasma following the energy deposition by the intense subpicosecond pulse can be viewed as the energy-impulse response of the plasma. Experimental results and modeling of the x-ray emission from this plasma will be presented. 15 refs., 8 figs.

8663 (RAL–89-065) **Antiprotonic-hydrogen atoms.** Batty, C.J.;. Rutherford Appleton Lab., Chilton (UK). Jul 1989. 112p. Order Number DE90611041. Available from NTIS (US Sales Only), PC A06/MF A01 - OSTI; INIS.

To be published in Reports on Progress in Physics.

Experimental studies of antiprotonic-hydrogen atoms have recently made great progress following the commissioning of the low energy antiproton facility (LEAR) at CERN in 1983. At the same time our understanding of the atomic cascade has increased considerably through measurements of the X-ray spectra. The life history of the p-bar-p atom is considered in some detail, from the initial capture of the antiproton when stopping in hydrogen, through the atomic cascade with the emission of X-rays, to the final antiproton annihilation and production of mesons. The experiments carried out at LEAR are described and the results compared with atomic cascade calculations and predictions of strong interaction effects. (author).

8664 **Evidence for correlated double-electron capture in slow O^{6+} + He collisions.** Phaneuf, R.A. (Oak Ridge National Lab., Oak Ridge, TN); Meyer, F.W.; Havener, C.C.; Stolterfoht, N.; Swenson, J.K.; Shafroth, S.M. pp. 124 of Dynamic processes of highly charged ions. Kanai, Y.; Ohtani, S Institute of Plasma Physics, Nagoya, Japan (1987). DOE Contract AC05-84OR21400. (CONF-860833–: 10. international conference on atomic physics, Tokyo (Japan), 25-29 Aug 1986).

Double electron capture by few-electron multicharged ions during slow collisions with He may result in Auger-decaying product states of the projectile, provided the initial projectile charge exceeds +4. These autoionizing states can be characterized by either (nearly) equivalent electron configurations, in which the two captured electrons occupy essentially the same or adjacent shells, or by non-equivalent configurations, in which one of the electrons is in a Rydberg state. Using the method of zero-degree Auger spectroscopy, the authors have verified population of both types of autoionizing states by double electron capture during slow collisions of O^{6+} with He: for these systems, both LMM Auger electrons, attributed to the (nearly) equivalent electron configuration ($1s^2$) 3iota3iota' or ($1s^2$)3iota4iota', and L_1L_{23}M-Coster Kronig electrons, attributed to the non-equivalent electron configurations ($1s^2$)2pniota, were observed. Comparison of the LMM Auger electron and Coster Kronig electron production cross sections suggests that the correlated double capture process is of comparable importance to the sequential single capture mechanism.

8665 **Anode foil changer for high-current relativistic electron beam diode systems.** Fine, T.A. (Electrical Engineering Department and Laboratory for Plasma Research, University of Maryland, College Park, Maryland 20742 (US)); Rhee, M.J. *Review of Scientific Instruments (USA),* 60(11): 3556-3557 (Nov 1989).

An anode foil changer for pulsed, high-current, relativistic electron beam diode systems is described. This device allows multiple shots to be taken with a foil-anode diode system while maintaining a continuous vacuum. Shot-to-shot reproducibility is greatly improved, while at the same time a significant time savings is realized. Also, various diagnostics and options are added to the basic design which further increase its utility and flexibility.

8666 **The effect of charge exchange processes on ion diode impedance.** Desjarlais, M.P. (Sandia National Laboratories, Albuquerque, New Mexico 87185 (US));. *Journal of Applied Physics (USA),* 66(10): 4696-4701 (15 Nov 1989). DOE Contract AC04-76DP00789.

A simple model of the effect of charge exchange processes on the steady-state ion current in a space-charge-limited ion diode is presented. The model is used to investigate the effect of charge exchange processes on ion diode impedance and virtual cathode motion.

8667 **Closed-form expression for $1s \rightarrow 1s$ electron-capture amplitude in a second-order Faddeev approximation.** Alston, S. (Department of Physics, Pennsylvania State University, Wilkes-Barre Campus, Lehman, Pennsylvania 18627 (US));. *Physical Review [Section] A: General Physics (USA),* 40(9): 4907-4913 (1 Nov 1989).

Within a second-order approximation to the Faddeev treatment of the exact transition operator for $1s \rightarrow 1s$ electron capture in ion-atom collisions, expressions are derived in terms of F_4 generalized hypergeometric functions for that part of the full amplitude involving electronic-nuclear potentials only. For totally symmetric collisions, the amplitude is evaluated in terms of ${}_3F_2$ functions. When near-the-energy-shell anomalies of the Coulomb scattering are neglected, the amplitude is seen to reduce to a symmetric impulse-approximation form, and, when the explicit Coulomb nature of the problem is neglected, to a second-order Born approximation form. As a special case, the amplitude is evaluated at the momentum transfer value where the differential cross section exhibits a local maximum—the Thomas peak. The values of the various amplitude norms at the Thomas peak are compared.

8668 Doubly differential detachment cross sections for 0.5-MeV H^- on He including projectile excitation to H(n=2). Liu, C. (Department of Physics and Astronomy, The University of Nebraska, Lincoln, Nebraska 68588-0111 (US)); Starace, A.F.;. *Physical Review [Section] A: General Physics (USA)*, 40(9): 4926-4940 (1 Nov 1989).

Detailed theoretical results are presented for the electron-detachment cross section, doubly differential in both the electron momentum and angle, for the process 0.5-MeV $H^-+He \rightarrow H(n=2)+e^-+He^+$. As discussed briefly elsewhere [C. R. Liu and A. F. Starace, Phys. Rev. Lett. 62, 407 (1989)], the laboratory-frame doubly differential cross sections (DDCS's) for electron detachment in the forward direction are shown to depend sensitively on the low-energy states of the H(n=2)-e^- three-body system. In particular, the angular dependence of characteristic cusp and shape resonance features is presented. We find that the projectile frame DDCS for detached electron energies in the vicinity of the shape resonance peak is nearly isotropic. This is due in part to the ^1P symmetry of the resonance feature, which limits the angular distribution to constant and $\cos^2\theta$ terms, and in part to cancellation in the integral over momentum transfer on which the coefficient of the $\cos^2\theta$ term depends.

8669 Large-angle scattering in positron-helium and positron-krypton collisions. Schultz, D.R. (Department of Physics and Laboratory for Atomic and Molecular Research, University of Missouri-Rolla, Rolla, Missouri 65401 (US)); Reinhold, C.O.; Olson, R.E.;. *Physical Review [Section] A: General Physics (USA)*, 40(9): 4947-4958 (1 Nov 1989).

We have calculated differential cross sections as a function of the projectile scattering angle for positron-helium and positron-krypton collisions using the classical-trajectory Monte Carlo technique. These intermediate-velocity collisions have been simulated by various independent-electron and n-electron models, using both screened Coulomb and quantum model potentials to approximate the effects of electron-electron interactions. These several models all indicate that scattering of positrons to large angles in ionizing collisions persists to high impact velocities. In a previous work [Phys. Rev. A 38, 1866 (1988)] we proposed that the recent experiments that have measured the total cross section for positronium formation could be affected by the loss of positron flux due to incomplete confinement after large-angle scattering. Here, utilizing these newly calculated differential-scattering cross sections, adjustments are computed that account for the difference between the experimental and theoretical behaviors of the positronium formation cross section. Further, it is demonstrated that large-angle scattering in the elastic channel is important for one of the experiments. We have also computed total cross sections for ionization and charge transfer for collisions of protons with krypton. Good agreement is obtained in these cases with experimental measurements.

8670 Oscillations of electron flux in photodetachment of H^- in an electric field. Du, M.L. (Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, Massachusetts 02138 (US));. *Physical Review [Section] A: General Physics (USA)*, 40(9): 4983-4987 (1 Nov 1989).

Outgoing electron waves produced in the photodetachment of H^- are propagated to large distances in a homogeneous electric field, and the electron flux is then computed. It is shown that the interference of waves propagating along two distinctive paths from the region of the bound state of H^- to the same point induces oscillations in the electron flux distribution. Simple analytic expressions are presented for the flux distribution.

8671 Density effects on high-n molecular Rydberg states: CH_3I and C_6H_6 in H_2 and Ar. Asaf, U. (Department of Chemistry, Louisiana State University, Baton Rouge, Louisiana, 70803 (US)); Felps, W.S.; Rupnik, K.; McGlynn, S.P.; Ascarelli, G. *Journal of Chemical Physics (USA)*, 91(9): 5170-5174 (1 Nov 1989).

The absorption spectra of high-n Rydberg states of methyl iodide and benzene perturbed by varying number densities of hydrogen or argon, range 0.9×10^{20}–10.5×10^{20} cm^{-3} for H_2 and 0.6×10^{20}–7.5×10^{20} cm^{-3} for Ar, have been investigated. The high-n molecular states of both absorbers were found to shift linearly with the number density of atomic Ar and molecular H_2 scatterers. The Fermi formula modified by the Alekseev–Sobel'man polarization term provides an excellent fit of the shift data. The electron scattering lengths obtained are: 0.93 a_0 for H_2 and −1.63 a_0 for Ar using the CH_3I absorber; and 0.99 a_0 for H_2 and −1.57 a_0 for Ar using the C_6H_6 absorber. The electron scattering lengths for H_2 and Ar agree with the results of an empirical model that correlates scattering lengths and the polarizabilities α(spherical) for inert atoms and α_2(nonspherical) for H_2 molecule.

8672 Molecular alignment from circular dichroic photoelectron angular distributions in (n+1) resonance enhanced multiphoton ionization. Dubs, R.L. (Molecular Spectroscopy Division, National Institute of Standards and Technology, Gaithersburg, Maryland 20899 (US)); McKoy, V. *Journal of Chemical Physics (USA)*, 91(9): 5208-5211 (1 Nov 1989).

The theory for determination of molecular alignment from circular dichroism in photoelectron angular distributions is generalized to treat the case in which the excitation polarization direction and the laboratory z axis do not coincide. A new method of data analysis is presented here. Alignment created by surface scattering or photofragmentation should be obtainable by these procedures. For studies of orientation with elliptically polarized excitation, differential cross sections at a given collection angle are found to be, to a good approximation, independent of excited-state alignment. Orientation can thus be obtained from *differential* cross sections by the methods developed by Kummel, Sitz, and Zare [J. Chem. Phys. 88, 6707 (1988)].

8673 Diode laser probing of the high-frequency vibrational modes of baths of CO_2, N_2O, and CO excited by relaxation of highly excited NO_2. Chou, J.Z. (Department of Chemistry and Columbia Radiation Laboratory, Columbia University, New York, New York 10027 (US)); Hewitt, S.A.; Hershberger, J.F.; Brady, B.B.; Spector, G.B.; Chia, L.; Flynn, G.W. *Journal of Chemical Physics (USA)*, 91(9): 5392-5401 (1 Nov 1989).

Quenching of highly excited vibrational states of NO_2 in baths of CO_2, N_2O, and CO has been investigated. Dilute NO_2 mixtures were excited by a pulse from an excimer pumped dye laser operating at 495 nm. The ν_3 antisymmetric stretching modes of CO_2 (2349 cm^{-1}) and N_2O (2223 cm^{-1}) and the v=1 level of CO (2143 cm^{-1}) were probed with continuous wave IR diode lasers. The amount of energy transferred from excited NO_2 to the ν_3 modes of both CO_2 and N_2O was found to be 3%±1% of the original excitation energy. On the other hand, a smaller amount of energy (0.9%±0.3%) was deposited into the CO vibrational mode for NO_2 contained in a dilute CO bath. These results support a picture of very inefficient transfer from high energy states of donor molecules to the high-frequency vibrational modes of small bath molecules. Differences in the efficiency of energy reception by the high-frequency modes of these three molecules scale roughly as the infrared transition moments for the bath states indicating the importance of resonance effects in the energy transfer process, but a combination of short- and long-range force mechanisms is probably necessary to account for the observed differences.

8674 Calculation of spin densities in diatomic first-row hydrides. Chipman, D.M. (Radiation Laboratory, University of Notre Dame, Notre Dame, Indiana 46556 (US)). *Journal of Chemical Physics (USA)*, 91(9): 5455-5465 (1 Nov 1989).

Fermi contact spin densities have been theoretically determined for the ground-state diatomic first-row hydrides CH, OH, and NH having open shell π electrons. Multiconfiguration self-consistent-field wave functions include the dominant configuration and single excitations from it describing the most important spin and orbital polarization effects. Optimization of the orbitals by precise numerical grid methods shows that this simple wave function model is capable of providing spin densities in satisfactory agreement with experiment. Gaussian basis sets suitable for use with this wave function model are determined by comparing to the precise numerical spin density results. Huzinaga's popular (9s5p|4s) primitive Gaussian basis provides a good starting point if augmented with diffuse and polarization functions and with a tight (high exponent) s function at hydrogen. Only the innermost few primitive functions may be contracted. Contraction coefficients may be determined on the basis of free atom Hartree–Fock calculations. These studies lead to economical contracted Gaussian basis sets that should be useful for spin density calculations on larger polyatomic radicals.

8675 Electron scattering in dense He-Ar gas mixtures: A pressure shift study. Asaf, U. (Department of Chemistry, Louisiana State University, Baton Rouge, Louisiana 70803 (US)); Felps, W.S.; McGlynn, S.P.;. *Physical Review [Section] A: General Physics (USA),* 40(9): 5458-5460 (1 Nov 1989).

The dependence of the energies of high-n Rydberg states of CH_3I on the molar composition of helium-argon mixtures (in the number density range 1.3×10^{20}–5.6×10^{20} cm^{-3}) is reported. The energy shifts, when normalized to a given density value, are found to vary linearly with the mole fraction of either component of the binary, rare-gas mixture. The observed change in sign of the energy shift is attributable to the different signs of the electron scattering lengths for the two rare-gas components. As a result, there exists a mixture composition, at a mole ratio [He]/[Ar]=2.0, at which the shift is null. The experimental results for the gas mixture agree with the Fermi formula, as modified to include the Alekseev-Sobel'man polarization term. Effective electron scattering lengths and cross sections, polarizabilities, and thermal velocities are used to characterize the effects of the binary gas perturber system.

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Refer also to citation(s) 7034, 8261, 8629, 8660, 8814

8676 (BUM–85) **Adaptive characteristic operator splitting techniques for convention-dominated diffusion problems in one and two space dimensions.** Dahle, H.K. Bergen Univ. (Norway). Dept. of Applied Mathematics. Dec 1988. 87p. Order Number DE90728217. Available from NTIS (US Sales Only), PC A05/MF A01.

In this report a new operator splitting technique, based on the modified method of characteristics, is analyzed. The method applies to convection dominated diffusion-convection problems which may develop shock solutions. Both theory and numerical results demonstrate that very long time steps can be used even in the presence of shock fronts, whithout significant loss of accuracy. The splitting makes it possible to closely model the physical convection by the approximate characteristics, which further allows for a simple and accurate treatment of the nonlinear coefficients. The method may easily exploit the multiple space scules introduced by shock solutions. Substructuring algorithms, combined with preconditioning techniques, gives an efficient and accurate way of modeling shock fronts. The use of Petrov-Galerkin formulation of the diffusion problem with transport terms, gives a stable numerical scheme, even when the coefficient in front of the diffusion term becomes singular or very small. If the shock is not properly resolved, the Petrov-Galerkin method spreads the front over a few fine grid blocks, and does not cause oscillations like standard Galerkin methods. 36 refs., 21 figs.

8677 Evolution and breaking of liquid film flowing on a vertical cylinder. Rosenau, P. (Department of Mechanical Engineering, Technion-Israel Institute of Technology, Haifa 32000, (IL)); Oron, A. *Physics of Fluids A: Fluid Dynamics (USA),* 1(11): 1763-1766 (Nov 1989).

An amplitude equation is derived, which describes the evolution of a disturbed film interface $H(\tau,Z,Y)$ flowing down an infinite vertical cylindrical column. Using a new approach, which accounts for fast spatial changes, the nonlinear evolution of the interface is shown to be governed by $H_\tau+\beta HH_Z+\alpha H_{ZZ}+\gamma\nabla^2\{N[(1/\omega^2)H+\nabla^2 H]\}=0$, where ω is the normalized cylinder radius and α, β, and γ are constants, $\nabla\equiv(\partial_Z, \partial_Y)$, and $N=[1+\epsilon^4(\nabla H)^2]^{-3/2}$. It is shown numerically that for some linearly unstable equilibria the evolving waves break in a finite time.

8678 Kinetic energy generated by the incompressible Richtmyer–Meshkov instability in a continuously stratified fluid. Saffman, P.G. (California Institute of Technology, Department of Applied Mathematics, Pasadena, California 91125 (US)); Meiron, D.I. *Physics of Fluids A: Fluid Dynamics (USA),* 1(11): 1767-1771 (Nov 1989).

The problem of calculating the kinetic energy created by impulsive acceleration of an incompressible continuously stratified fluid is formulated. Solutions are obtained for small density perturbations and a particular profile for various Atwood numbers and length scales. The kinetic energy is reduced when the undisturbed density variation is more diffuse.

8679 Symmetries within chaos: A route to effective mixing. Franjione, J.G. (Department of Chemical Engineering, University of Massachusetts, Amherst, Massachusetts 01003 (US)); Leong, C.; Ottino, J.M. *Physics of Fluids A: Fluid Dynamics (USA),* 1(11): 1772-1783 (Nov 1989).

Experimental studies show that simple two-dimensional time-periodic flows can produce chaotic mixing. However, the mixing is not always complete; depending on the choice of the period, there can exist large dynamic structures, called *islands*, that stretch and compress in a time-periodic manner but remain segregated even after long times. Obviously, a flow that contains very few islands is desired. Unfortunately, in most real systems, an analytic expression for the velocity field (or the motion) does not usually exist, making theoretical prediction of the location and size of islands virtually impossible. However, using only minimal knowledge of the gross properties of the velocity field, the flow can be analyzed in terms of its symmetries. Symmetries can be detected without reference to precise mathematical equations. Large islands are located on lines of symmetry, or in pairs on opposite sides of the line. With this knowledge, it is possible to manipulate symmetries in a systematic way so as to move an island into a region of good mixing. Applying this idea repeatedly results in a recursively generated flow history that is neither periodic nor random, but is self-similar. Mixing in these flows is efficient over the entire flow domain. In addition, the idea of recursively generated flow histories might have implications for understanding the mechanisms of turbulent flow.

8680 Structure of Lagrangian turbulence. Viecelli, J.A. (Lawrence Livermore National Laboratory, Livermore, California 94550 (US)). *Physics of Fluids A: Fluid Dynamics (USA),* 1(11): 1836-1843 (Nov 1989). DOE Contract W-7405-ENG-48.

A structure function describing the geometrical properties of Lagrangian turbulence is proposed. This function yields the asymptotic mixing properties of inertial range turbulence. The form of the structure function is deduced from Richardson's particle dispersion law. Scaling relationships for the mixing volume fraction, the surface area of boundaries between materials, and the chord lengths defined by the intersection points of a ray with material boundaries are obtained. Scaling laws are also deduced for the area fraction, perimeter length, and chord lengths in a two-dimensional section, and for the trajectory of a single particle. The predictions for the two-dimensional case have been verified in several examples of mixing, using data obtained from numerical integration of the Navier–Stokes equations.

8681 Non-Gaussian statistics in isotropic turbulence. Chen, H. (Los Alamos National Laboratory, Los Alamos, New Mexico 87545 (US)); Herring, J.R.; Kerr, R.M.; Kraichnan, R.H. *Physics of Fluids A: Fluid Dynamics (USA),* 1(11): 1844-1854 (Nov 1989). DOE Contract W-7405-ENG-36.

Several measures of non-Gaussian behavior in simulations of decaying isotropic turbulence are compared with predictions of the direct-interaction approximation (DIA) at an initial $R_\lambda\approx35$. The quantities studied include the variances and wavenumber power spectra of (a) the total nonlinear term in the Navier–Stokes equation, (b) the time derivative of the velocity at a point, (c) pressure fluctuations, and (d) vorticity and dissipation fluctuations. The direct-interaction approximation gives a good quantitative prediction of the variance of the time derivative and the variance of total nonlinear term, and a fair qualitative prediction of the power spectrum associated with the latter. But DIA totally fails to capture the non-Gaussian statistics associated with pressure fluctuation and vorticity spottiness. Some discussion is given of demands that vorticity and dissipation statistics place upon theories of tubulence at moderate and high Reynolds numbers.

8682 WKB theory of wave tunneling for Hermitian and nearly Hermitian vector systems of integral equations. Kull, H.J. (Institute for Fusion Studies, The University of Texas at Austin, Austin, Texas 78712 (US)); Kashuba, R.J.; Berk, H.L. *Journal of Mathematical Physics (New York) (USA),* 30(11): 2527-2544 (Nov 1989).

A general theory of wave tunneling in one dimension for Hermitian and nearly Hermitian vector systems of integral equations is presented. It describes mode conversion in terms of the general dielectric tensor of the medium and properly accounts for the forward and backward nature of the waves without regard to specific models. Energy conservation in the WKB approximation can be obtained for general Hermitian systems by the use of modified Furry rules that are similar to those used by Heading for second-order differential equations. Wave energy absorption can then be calculated perturbatively using the conservation properties of the dominant Hermitian operator. Operational graphical rules are developed to construct global wave solutions and to determine the direction of energy flow for spatially disconnected roots. In principle, these rules could be applied to systems with arbitrary mode complexity. Coupling coefficients for wave tunneling problems with up to four interacting modes are calculated explicitly.

8683 **Explicit growth rates for the Rayleigh-Taylor instability in exponential density profiles.** Mikaelian, K.O. (Lawrence Livermore National Laboratory, Livermore, California 94550 (US));. *Physical Review [Section] A: General Physics (USA),* 40(8): 4801-4803 (15 Oct 1989). DOE Contract W-7405-ENG-48.

We consider the Rayleigh-Taylor instability in exponential density profiles and derive two approximate expressions for the growth rate that are explicit and involve only the Atwood number *A* and the wave number *k*. Our results agree with the exact growth rate within 6–12 %. We also point out that a recently published expression deviates from the exact growth rate for practically all values of *A* and *k* [M. H. Emery, J. P. Dahlburg, and J. H. Gardner, Phys. Fluids 31, 1007 (1988)].

8684 **Saffman-Taylor–type instability in a lattice gas.** Burgess, D. (Department of Physics, The Ohio State University, 174 West 18th Avenue, Columbus, Ohio 43210 (US)); Hayot, F.;. *Physical Review [Section] A: General Physics (USA),* 40(9): 5187-5192 (1 Nov 1989).

We show how a Saffman-Taylor-type fingering instability emerges in lattice-gas hydrodynamics. We discuss linear stability and the effect of noise which is intrinsic to the algorithm. Noise leads to a tip-splitting instability of the evolving finger.

8685 **Phase-space singularities in atomistic planar diffusive flow.** Hoover, W.G. (Department of Applied Science, University of California at Davis-Livermore, CA (USA)—Lawrence Livermore National Laboratory, Livermore, California 94550 (US)); Moran, B.;. *Physical Review [Section] A: General Physics (USA),* 40(9): 5319-5326 (1 Nov 1989). DOE Contract W-7405-ENG-48.

Morriss [Phys. Rev. A 39, 4811 (1989)] recently published a stimulating study of a nonequilibrium Lorentz gas. He measured a multifractal "spectrum of singularities" $f(a)$ describing the "coarse-grained" phase space-representation of a time-reversible, two-body, space- and time-periodic shear flow. The measured function $f(a)$ is the "Hausdorff dimension" of attractor singularities whose local bin integrals vary as the ath power of the bin length. Morriss found a spectrum of singularities $f(a)$ very different from those familiar to nonlinear dynamical systems theory. Here we consider a closely related, but simpler, two-body time-reversible atomistic system. It is also a Lorentz-gas problem, a nonequilibrium diffusive flow, periodic in space but stationary in time. This system appears to be both mixing and ergodic, even far from equilibrium. We use the Chhabra-Jensen technique to show that the phase-space singularity spectrum $f(a)$ for this nonequilibrium flow more closely resembles those of dynamical systems theory.

6450 High Energy Physics

Refer also to citation(s) 8343

6451 Particle Interactions and Properties - Experimental

Refer also to citation(s) 8720, 8754, 8755, 8758, 8761, 8769, 8852

8686 (CERN–89-08(v.1)) **Z physics at LEP 1. Vol. 1: Standard physics.** Altarelli, G.; Kleiss, R.; Verzegnassi, C. (eds.);. European Organization for Nuclear Research, Geneva (Switzerland). 21 Sep 1989. 457p. Order Number DE90611488. Available from NTIS (US Sales Only), PC A20/MF A01 - OSTI; INIS.

The contents of this final report from the Workshop on Z Physics at LEP can be divided into two parts. The first part, comprising Vols. 1 and 2, is a relatively concise but fairly complete handbook on the physics of e^+e^- annihilation near the Z peak (with normal LEP luminosity and unpolarized beams, appropriate for the first phase of LEP operation). The second part (Vol. 3) is devoted to a review of the existing Monte Carlo event generators for LEP physics. A special effort has been made to co-ordinate the different parts of this report, with the aim of achieving a systematic and balanced review of the subject, rather than having simply a collection of separate contributions. (orig.).

8687 (CERN–89-08(v.2)) **Z physics at LEP 1. Vol. 2: Higgs search and new physics.** Altarelli, G.; Kleiss, R.; Verzegnassi, C. (eds.);. European Organization for Nuclear Research, Geneva (Switzerland). 21 Sep 1989. 215p. Order Number DE90611489. Available from NTIS (US Sales Only), PC A10/MF A01 - OSTI; INIS.

The contents of this final report from the Workshop on Z Physics at LEP can be divided into two parts. The first part, comprising Vols. 1 and 2, is a relatively concise but fairly complete handbook on the physics of e^+e^- annihilation near the Z peak (with normal LEP luminosity and unpolarized beams, appropriate for the first phase of LEP operation). The second part (Vol. 3) is devoted to a review of the existing Monte Carlo event generators for LEP physics. A special effort has been made to co-ordinate the different parts of this report, with the aim of achieving a systematic and balanced review of the subject, rather than having simply a collection of separate contributions. (orig.).

8688 (CONF-8901115–7) **Results from FNAL E745 on neutrino-nucleus interactions (EMC effect and hadron formation).** Kitagaki, T. (Tohoku Univ., Sendai (Japan). Bubble Chamber Physics Lab.). FNAL E745 collaboration. Fermi National Accelerator Lab., Batavia, IL (USA). [1989]. 21p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH03000;AC05-84OR21400;AS05-76ER03956. From Topical conference on electronuclear physics with internal targets; Stanford, CA (USA); 9-12 Jan 1989. Order Number DE90003836. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The dark tracks (stubs) in high energy neutrino-nucleus interactions in the Tohoku High Resolution Freon Bubble Chamber are investigated. Classifying events into groups by using the dark tracks, correlations between the dark track production and neutrino interactions are studied. Events without dark tracks comprise a reasonable sample of events which occurred on quasi-free nucleons inside nucleus. By comparing the groups using the no dark track group as a comparison sample instead of neutrino-deuterium events, the EMC effect and hadron formation are investigated. This method provides new results which differ somewhat from the conventional data for the EMC effect and formation-rescattering. 10 refs., 17 figs.

8689 (JINR-D–1-13-88-172) **International symposium on position detectors in high energy physics. Proceedings.** Joint Inst. for Nuclear Research, Dubna (USSR). 1988. 404p. (CONF-8709252–: International symposium on position detectors for high energy physics, Dubna (USSR), 22-25 Sep 1987). Order Number DE90705987. Available from NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS.

Individual papers in these proceedings are separately indexed.

8690 (NIKHEF-H–89-9) **Exclusive production of p anti $p\pi^+\pi^-$ in photon photon collisions.** Aihara, H. (Lawrence Berkeley Lab., CA (USA)); Alston-Garnjost, M.; Avery, R.E. TPC-Two-Gamma Collaboration. Nationaal Inst. voor Kernfysica en Hoge-Energiefysica (NIKHEF), Amsterdam (Netherlands). Sectie H. Apr 1989. 16p. Order Number DE90705950. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI.

A measurement of the $e^+e^- \rightarrow e^+e^-p$ anti $p\pi^+\pi^-$ process with the TPC-Two-Gamma facility at the PEP e^+e^- storage ring at SLAC is reported. Forty-five p anti $p\pi^+\pi^-$ events were identified in data corresponding to an integrated e^+e^- luminosity of 142 pb^{-1}. The cross section for $\gamma\gamma \rightarrow$ p anti $p\pi^+\pi^-$ is given both as a function of $W_{\gamma\gamma}$, the $\gamma\gamma$ center-of-mass energy, with $W_{\gamma\gamma}$ between 2.5 and 5.5

GeV, and as a function of the invariant mass squared, q^2, of one of the photons, with $-q^2 < 7$ GeV^2. This cross section falls much less rapidly with $W_{\gamma\gamma}$ than does the cross section for a similar process, $\gamma\gamma \rightarrow p$ anti p. No Δ^0 anti Δ^0 production is observed, and only a small fraction of the events at low $W_{\gamma\gamma}$ is consistent with $\gamma\gamma \rightarrow \Delta^{++}$ anti Δ^{--}. Δ^{++} anti $p\pi^-$ or anti $\Delta^{--}p\pi^+$. In an expanded search through the same data, four events compatible with either Λ anti Λ ($\Lambda \rightarrow p\pi^-$) or Σ^0 anti $\Lambda(\Sigma^0 \rightarrow \Lambda\gamma)$ production were found. 14 refs., 5 figs., 1 tab.

8691 (SLAC–353) **The physics program of a high-luminosity asymmetric B Factory at SLAC.** Stanford Linear Accelerator Center, Menlo Park, CA (USA). Oct 1989. 248p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00098;AC03-81ER40050. (LBL–27856;CALT–68-1588). Order Number DE90004450. Available from NTIS, PC A12/MF A01; OSTI; INIS; GPO Dep.

A high-luminosity asymmetric energy B Factory, proposed as an upgrade to the PEP storage ring at SLAC, provides the best opportunity to study CP violation as a means of testing the consistency of the Standard Model. If the phenomenon of CP violation is explained by the Standard Model simply through the non-zero angles and phase of the Kobayashi-Maskawa matrix, then there are precise relations between the K-M parameters and the various measurable CP-violating asymmetries in B meson decay. Should these consistency relations fail, the origin of CP violation must lie outside the Standard Model framework. Our measurements would then lead to the first experiment-driven extensions of the Standard Model. The B Factory will also carry out a varied, high-quality program of studies of other aspects of the physics of b quarks, as well as high-precision measurements in τ and charm physics. We describe a detailed series of measurements to be carried out in the first few years at a peak luminosity of 3×10^{33} cm^{-2}sec^{-1}, the initial luminosity goal of the B Factory, as well as the program accessible to a larger data sample.

8692 **Summary of the 8th international symposium on high energy spin physics.** Bunce, G. (Brookhaven National Laboratory, Upton, New York 11973 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 1-16 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

This article presents a summary of the 8th International Symposium on High Energy Spin Physics which was held at the University of Minnesota in Minneapolis, Minnesota from September 12-17, 1988. This conference was concerned with both the technology of spin and with particle physics, i.e., particle physicists need to know what experiments might be possible and target/beam/source physicists want to know what their work will lead to, and get new ideas.

8693 **Analyzing-power measurements of Coulomb-nuclear interference with the polarized-proton and -antiproton beams at 185 GeV/c.** Akchurin, N. (Iowa Univ., Iowa City, IA (USA). Dept. of Physics); Onel, Y.; Carey, D.; Coleman, R.; Cossairt, J.D.; Read, A.L.; Corcoran, M.D.; Nessi-Tedaldi, F.; Nessi, M.; Nguyen, C. E-581/704 Collaboration. *Physics Letters [Section] B (Netherlands),* 229(3): 299-303 (12 Oct 1989). DOE Contract W-31-109-ENG-38;AC02-76CH03000;AC02-76ER02289;W-74

The analyzing power A_N of proton-proton, proton-hydrocarbon, and antiproton-hydrocarbon scattering in the Coulomb-nuclear interference region has been measured using the 185 GeV/c Fermilab polarized-proton and -antiproton beams. The results are found to be consistent with theoretical predictions within statistical uncertainties. (orig.).

8694 **Asymmetry in lepton pair production from e^+e^- at KEK.** Kim, S.K. (KEK, National Laboratory for High Energy Physics, Tsukuba, Ibaraki 305 (JP)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 280-290 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

Measurement of the forward-backward charge asymmetry for $e^+e^- \rightarrow \mu^+\mu^-$ and $e^+e^- \rightarrow \tau^+\tau^-$ processes at $\sqrt{s}$=52, 55, and 56 GeV TRISTAN is reported. Results from all three groups, AMY, TOPAZ, and VENUS are in good agreement with the expectation of the standard model of the electroweak interaction.

8695 **Experimental status of weak radiative decays.** James, C. (MS122 Physics Dept., Fermilab, Batavia, IL 60510 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 435-439 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

A summary of data for the weak radiative decays of hyperons (baryon→baryon+photon) is presented. Branching ratios and asymmetry parameters are given. Comparison with theoretical models is given. (AIP)

8696 **Complete sets of spin observables in pion-nucleon elastic scattering at 427–657 MeV/c.** Sadler, M.E. (Abilene Christian University, Abilene, TX 79699 (US)); Lane, D.W.; Loe, S.R.; Supek, I.; Barlow, D.B.; Kim, G.J.; Nefkens, B.M.K.; Pillai, C.; Wightman, J.A.; Briscoe, W.J.; and others. *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 597-601 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

Recent measurements of the spin rotation parameters A and R for pion-nucleon (πN) elastic scattering and analyzing powers for πN charge exchange at 427–657 MeV/c are presented. These measurements complete a program of πN experiments in this momentum region, marking the first time that complete data sets have been obtained at any momentum for this reaction. Comparisons are made with the recent SM88 partial wave analysis from VPI and the older Karlsruhe-Helsinki and Carnegie-Mellon-Berkeley analyses.

8697 **NN → NNπ at LAMPF and TRIUMF.** Riley, P.J. (University of Texas at Austin, Austin, TX 78712 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 613-622 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

This paper describes a partial wave analysis of pp → npπ^+ spin correlation measurements at LAMPF in the energy range 500–800 MeV. The large amplitudes for $^1D_2$, $^3D_2$ and $^3F_3$ NN → NΔ and for $^3P_1$ NN → NS are well determined and rather insensitive to variations in the fit. We interpret the data as evidence against broad dibaryons in this energy range. The NΔ S-wave phase shift provides evidence for an attractive NΔ threshold interaction. Planned np → ppπ^- spin dependent measurements at both TRIUMF and LAMPF are described.

8698 **Possible effect of the local terrain on the North Carolina tower gravity experiment.** Bartlett, D.F. (Department of Physics, University of Colorado, Boulder, Colorado 80309 (US)); Tew, W.L.;. *Physical Review Letters (USA),* 63(14): 1531 (2 Oct 1989).

A Comment on the Letter by D. H. Eckhardt, *et al.*, Phys. Rev. Lett. 60, 2567 (1988).

8699 **Study of the decay $\bar{B}^0 \rightarrow D^+l^-\bar{\nu}$.** Bortoletto, D.,et.al. (Syracuse University, Syracuse, New York 13244 (US)). *Physical Review Letters (USA),* 63(16): 1667-1670 (16 Oct 1989).

Using a sample of 484 000 *B* mesons collected with the CLEO detector at the Cornell Electron Storage Ring, we have measured $B(\bar{B}^0 \rightarrow D^{*+}l^-\nu)$ and found that the polarization of the D^{*+} is small. These results are compared with models of semileptonic *B* decay.

6452 Particle Interactions and Properties - Theoretical

Refer also to citation(s) 8650, 8685, 8686, 8721, 8725, 8733, 8788

8700 (CERN–89-08(v.3)) **Z Physics at LEP 1. Vol. 3: Event generators and software.** Altarelli, G.; Kleiss, R.; Verzegnassi, C. (eds.);. European Organization for Nuclear Research, Geneva (Switzerland). 21 Sep 1989. 344p. Order Number DE90611465. Available from NTIS (US Sales Only), PC A15/MF A01 - OSTI; INIS.

The contents of this final report from the Workshop on Z Physics at LEP can be divided into two parts. The first part, comprising Vols. 1 and 2, is a relatively concise but fairly complete handbook on the physics of e^+e^- annihilation near the Z peak (with normal LEP luminosity and unpolarized beams, appropriate for the first phase of

LEP operation). The second part (Vol. 3) is devoted to a review of the existing Monte Carlo event generators for LEP physics. A special effort has been made to co-ordinate the different parts of this report, with the aim of achieving a systematic and balanced review of the subject, rather than having simply a collection of separate contributions. (orig.).

8701 (DOE/ER/40448–2) **Theoretical aspects of electroweak and other interactions in medium energy nuclear physics: interim project report, December 8, 1989.** Mukhopadhyay, N.C. Rensselaer Polytechnic Inst., Troy, NY (USA). Dept. of Physics. 1989. 28p. Sponsored by U.S. DOE Energy Research. DOE Contract FG02-88ER40448. Order Number DE90004015. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

In the project year 1989–1990, progress has been made towards the theoretical modeling of the photoproduction of eta mesons off nucleons and in complex nuclei. Exploration of hadron models has produced interesting perspectives on the violation of gauge invariance due to truncation of the quark model space. New projects in perturbative quantum chromodynamics and spectrum generating algebras for hadrons have been started.

8702 (KFKI–1989-27/A) **Description of the scaled moments for the nondiffractive pp and pp^- interactions in the cms energy range 10-900 GeV.** Krasznovszky, S.; Wagner, I.;. Hungarian Academy of Sciences, Budapest (Hungary). Central Research Inst. for Physics. May 1989. 12p. Order Number DE90611469. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The authors propose a multiplicity distribution obtained by means of a geometrical model in the impact parameter representation. A remarkably good agreement is obtained between the model and experiments in respect of the second, third, fourth and fifth scaled moments at cms energies between 10-900 GeV for the full phase space. The authors predict the multiplicity distribution for radical = 1.8 TeV. (author) 11 refs.; 1 fig.; 3 tabs.

8703 (LA-UR–89-4026) **Neutrino oscillations: An essay in honor of Felix Boehm.** Rosen, S.P. Los Alamos National Lab., NM (USA). 1989. 16p. Sponsored by U.S. DOE Energy Research. DOE Contract W-7405-ENG-36. (CONF-8909273–1: Symposium in honor of Felix Boehm, Pasadena, CA (USA), 7-9 Sep 1989). Order Number DE90003223. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

We briefly review the theory of neutrino oscillations and the MSW effect and report on new calculations by Rosen and Gelb for solar neutrino-electron scattering. The aim of these calculations is to try to use the scattering process as a means of choosing between the three types of MSW solutions for the ^{37}Cl experiment. Both the efficiency and the resolution of the Kamiokande II detector are taken into account and the ratio R of the MSW prediction to the standard solar model prediction is calculated for different cuts on the minimum electron energy. We find that the adiabatic solution requires R to be less than 1/3, the large angle one requires it to be less than 2/3, and the nonadiabatic one restricts it to a value close to 1/2. The central value of the published KII data is close to 1/2, but the errors are too large to exclude the other solutions. 20 refs., 1 fig.

8704 (RAL–89-072) **New variations on two old themes - String Theory and Baryonium: (Contribution to the Van Hove Festschrift).** Chan Hong-Mo;. Rutherford Appleton Lab., Chilton (UK). Jul 1989. 14p. Order Number DE90611470. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

A trace factor introduced twenty years ago to incorporate internal symmetry into String Theory is generalised to include also string dynamics, while some new spectroscopic data are examined in relation to a ten year old model of exotic qq-q-barq-bar mesons. (author).

8705 (RRK–89-20) **Approximate —Deltal— = 1/2 rule in K yields pipi decays from asymptotic quark-line diagram approach.** Terasaki, K.; Oneda, S. Hiroshima Univ., Takehara (Japan). Research Inst. for Theoretical Physics. Jul 1989. 16p. Order Number DE90733101. Available from NTIS (US Sales Only), PC A03/MF A01.

A general method which copes with both the long and short distance physics aspects of nonleptonic weak interactions in presented. First, the four-point decay amplitude can be expressed in terms of the three-point asymptotic matrix elements of the effective weak Hamiltonian H_w, taken between the on-mass-shell single-hadron states with infinite momenta. The study of these matrix elements in terms of the quark-lines in the infinite momentum frame reveals that, for the K yields pipi decays, those involving only the ordinary (QQ-bar) mesons do satisfy the strict —Deltal— = 1/2 rule. However, the contribution of the (QQ) (Q-barQ-bar) type exotic mesons leads explicitly to a small violation of the selection rule. (author).

8706 (SLAC-PUB–5055) **A perspective on lepton-photon physics.** Panofsky, W.K.H.;. Stanford Linear Accelerator Center, Menlo Park, CA (USA). Nov 1989. 12p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00515. (CONF-8908142–2: 14. international symposium on lepton and photon interactions, Stanford, CA (USA), 7-12 Aug 1989). Order Number DE90004612. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

This paper reviews some key experiments of the past in which the same basic physical processes are attacked both through lepton-photon interaction and by using hadron machines as primary tools. Not surprisingly, it is concluded that the basic distinction between lepton-photon physics and elementary particle physics in general is unreal but that the tools and methodology can be very different indeed. A look is then taken into the expected future evolution of particle accelerators. Existing accelerator technologies both for proton and electron colliders are approaching basic limits as the collision energy in the constituent frame is raised. At this time no clear path exists for electron-positron colliders to compete with the SSC as far as energy reach is concerned, but the superior clarity and coverage of phenomena not accessible to hadron colliders makes it absolutely essential that the development of both electron-positron and hadron colliders be pursued vigorously. It is concluded that accelerator R&D effort underway is insufficient if a large hiatus in productivity in particle physics is to be avoided. Electron-positron linear colliders are the most promising approach for the extension of knowledge beyond LEP and beyond the SSC, but the difficulties to reach an electron-positron energy of 15 TeV or beyond in the constituent frame look formidable. Both electron-positron and proton colliders appear to face severe future detector limitations, the former due to electron-positron pair creation during the collision and the latter due to the enormous hadronic background event rates. 6 refs., 7 figs.

8707 **Low-energy phenomenology of superstring-inspired E_6 models.** Hewett, J.L. (Wisconsin Univ., Madison (USA). Dept. of Physics); Rizzo, T.G. *Physics Reports: A Review Section of Physics Letters (Section C) (Netherlands),* 183(5/6): 193-381 (Nov 1989). DOE Contract AC02-76ER00881;W-7405-ENG-82.

In this report we survey the low-energy phenomenological implications of superstring-inspired E_6 models. The motivation for such models is reviewed. New particles including new gauge bosons, exotic fermions, Higgs bosons, and their superpartners are expected to exist in models of this type. We summarize the present experimental limits on these particles from both accelerator and non-accelerator data. Techniques for producing these new particles directly at existing and planned colliders as well as for searching for their indirect effects are examined in detail. Other phenomenological implications of such models are also reviewed. (orig.) With 330 refs.

8708 **Exclusive processes in QCD and spin-spin correlations.** De Teramond, G.F. (Stanford Linear Accelerator Center, Stanford University, Stanford, California (USA)— Escuela de Fisica, Universidad de Costa Rica, San Jose, Costa Rica). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 138-144 (1 May 1989). DOE Contract AC03-76SF00515. (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

The unexpected spin behavior observed in hard proton-proton collisions is described in terms of new degrees of freedom associated with the onset of strange and charmed thresholds. The deviation from dimensional scaling laws, the anomalous broadening of angular distributions, and the unusual energy dependence of *pp* quasielastic scattering in nuclear targets are also consistent with the onset of highly inelastic contributions to elastic *pp* amplitudes interfering with a perturbative QCD background. The model predicts significant

charm production above 12 GeV/c and a relaxation of the spin correlation parameters to their scaling values at higher energies.

8709 Determining quark helicity from jet distributions. Goldstein, G.R. (Department of Physics, Tufts University, Medford, Massachusetts 02155 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 291-294 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

A phenomenological method is presented for determining the helicity of a single heavy quark from the distribution of hadrons in the accompanying jet. The cleanest example of this effect is the *c*-quark fragmentation into D and π or D^* mesons. The production of a *c*-quark pair in the parity violating region of e^+e^- annihilation provides a test, but is expected to be small. On the other hand there will be a striking double correlation of helicities for two D^* fragments from a pair of *c*-quarks due to the strong correlation between the *c*-quarks in the annihilation process. The predicted azimuthal double decay distribution depends on the veracity of the QCD picture of the jet fragmentation process and the Standard Model and is quite accessible experimentally.

8710 Theory of the Z^0 polarization asymmetry. Kennedy, D.C. (Stanford Linear Accelerator Center, Stanford University, Stanford, California 94309 (US)—Department of Physics, Stanford University, Stanford, California 94305 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 244-262 (1 May 1989). DOE Contract AC03-76SF00515. (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

The polarization asymmetry of the Z^0 is a highly accurate measure of the Z^0 coupling to fermions and significant as a precision test of the Standard Model. We summarize the role of electroweak symmetry-breaking and radiative corrections; the non-decoupling of new physics beyond the Z^0; and the testing of extensions of the Standard Model, such as supersymmetry, technicolor, new generations of fermions, grand unification, and new gauge forces. Also discussed are the relationship of the polarization asymmetry to other electroweak observables and its superiority to other Z^0 asymmetries.

8711 B meson physics with polarized electron beams at the SLC. Atwood, W.B. (Stanford Linear Accelerator Center, Stanford University, Stanford, California 94309 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 271-279 (1 May 1989). DOE Contract AC03-76SF00515. (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

The expected large cross-section for $e^+e^- \rightarrow Z^0$ and subsequent decay to $b\bar{b}$ quarks makes the Z^0 an attractive place to pursue *B* meson physics. In addition the big Electroweak asymmetries, thought to exist in Z^0 decays to $b\bar{b}$ quarks with polarized electron beams, provide an outstanding handle for observation of such effects at B–$\bar{B}^0$ mixing. In this paper, the feasibility of such measurements is investigated and, with relatively small samples of Z^0's (a few hundred thousand), both B_d and B_s meson mixing are shown to be measurable. The subject of CP violation in neutral *B* mesons is discussed last, but presently such measurements seem to be out of reach. (AIP)

8712 Baryonic leptonic decays. Beretvas, A. (Fermi National Accelerator Laboratory, Batavia, Illinois 60510 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 428-434 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

Results from deep inelastic scattering of longitudinally polarized muons by longitudinally polarized protons at large Q^2 show that only a small fraction of the proton spin is due to quarks. This seems inconsistent with our understanding of the magnetic moments of the hyperons which agree reasonable well with the assumption that all of the spin of the baryon at $Q^2=0$ is carried by its valence quarks. Recent beta decay correlation measurements show that approximately half (0.55 ± 0.03) the spin of the proton is carried by the valence quarks.

8713 Pion-exchange contribution to the parity-violating asymmetry in pp scattering. Silbar, R.R. (Los Alamos National Laboratory, Los Alamos, NM 87545 (US)); Kloet, W.M.; Kisslinger, L.S.; Dubach, J. *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 474-481 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

Charged pion exchange, producing $n\Delta^{++}$ intermediate states, contributes negatively to the weak scattering asymmetry in longitudinally-polarized pp scattering. Including this contribution moves the theoretical prediction away from the 800 MeV experimental datum. The pion-exchange contribution has both inelastic and elastic scattering components and is sizeable even below the pion production threshold. Strong distortions enhance the magnitude of the effect.

8714 Intermediate-energy hadron interactions, II. Silbar, R.R. (Los Alamos National Laboratory, Los Alamos, NM 87545 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 540-549 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

This talk is a summary of the parallel session on intermediate-energy hadron reaction at the Eighth International Symposium on High-Energy Spin Physics held in Minneapolis, Minnesota (September 12–17, 1988). The topics covered were developments in $NN \rightarrow NN\pi$ reactions, dibaryons, elastic proton-deuteron scattering, and inelastic proton-alpha scattering. Lastly a short remark about two peculiarities that were found by theorists looking at strong interaction amplitudes. (AIP)

8715 Spin observables and exotic resonances (strange and non-strange). Lomon, E.L. (Center for Theoretical Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 630-640 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

This presentation discusses (i) the energy at which exotics are likely to be found; (ii) their effect on observables; and (iii) the present evidence for exotics in the nucleon-nucleon channel. (AIP)

8716 Gluon fusion as a source for massive quark polarization. Dharmaratna, W.G.D. (Department of Physics, Tufts University, Medford, MA 02155 (US)); Goldstein, G.R. *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 744-746 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

We have explored the possibility of polarization of quarks through "Gluon Fusion," assuming that the quark mass can be significant at energies of interest. The fourth order contribution to the single spin asymmetry is calculated. A rough fit to the hyperon polarization data is given. It is claimed that the gluon fusion can be taken as a serious candidate for the 'seed' of polarization.

8717 Implications of recent $M_{Z,W}$ and neutral-current measurements for the top-quark mass. Langacker, P. (Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania 19104-6396 (US));. *Physical Review Letters (USA),* 63(18): 1920-1921 (30 Oct 1989).

The implications of precise new *Z*- and *W*-mass and weak-neutral-current data for the top-quark and Higgs-boson masses are analyzed. It is found that (a) $\sin^2\theta_W=0.226\pm0.005$ for arbitrary m_t and for all $M_H<1$ TeV; (b) $m_t<210$ GeV at 90% C.L.; (c) $m_t>40$ GeV at 90% C.L., even if the direct lower limit $m_t>78$ GeV does not apply; and (d) there is no constraint on the Higgs-boson mass.

8718 Analytical and numerical study of the Schwinger-Dyson equation with four-fermion coupling. Takeuchi, T. (Center for Theoretical Physics, Department of Physics, Yale University, New Haven, Connecticut 06511 (US)). *Physical Review [Section] D: Particles and Fields (USA),* 40(8): 2697-2707 (15 Oct 1989).

The dressed ladder Schwinger-Dyson equation for the fermion self-energy $\Sigma(p^2)$ with an additional four-fermion coupling term is studied both analytically and numerically. We limit our analysis to

asymptotically free theories with a large hierarchy between the confinement scale Λ_c and the ultraviolet cutoff Λ. The dependence of the dynamical mass Σ_0 identical $\Sigma(0)$ and the fermion condensate $\langle \Psi\Psi \rangle$ on the four-fermion coupling strength λ is derived. It is found that there exists a critical four-fermion coupling strength λ_2, such that in the region $\lambda<\lambda_2$ the dynamical mass Σ_0 is of the order of the confinement scale Λ_c, while in the region $\lambda>\lambda_2$ the dynamical mass Σ_0 is of the order of the cutoff Λ. In the region $\lambda<\lambda_2$, the condensate $\langle \Psi\Psi \rangle$ picks up an enhancement factor $\lambda_2/(\lambda_2-\lambda)$, and in the limit $\lambda\rightarrow\lambda_2$, reaches the order of $\Lambda^2\Lambda_c$. In the region $\lambda>\lambda_2$, the condensate $\langle \Psi\Psi \rangle$ is of the order of Λ^3. The application of the equation to technicolor theories is also discussed.

8719 **Effect of a finite quark mass on the deconfinement temperature as calculated in dual QCD.** Baker, M. (University of Washington, Seattle, Washington 98105 (US)); Ball, J.S.; Zachariasen, F. *Physical Review [Section] D: Particles and Fields (USA),* 40(8): 2732-2735 (15 Oct 1989).

We calculate, to lowest order, the cotnribution of quark loops to the finite-temperature vacuum energy density. From this, in the high-temperature approximation, we obtain the dual QCD deconfinement transition temperature as a function of the input quark mass.

6453 Particle Invariance Principles and Symmetries

Refer also to citation(s) 8691, 8707, 8708, 8709, 8710, 8712, 8715, 8744, 8745, 8754, 8755, 8759, 8760, 8761, 8762, 8768

8720 (ITF–88-70) **Effective Hamiltonians and the theory of invariants.** Asherova, R.M.; Zhilinskij, B.I.; Pavlov-Verevkin, V.B.; Smirnov, Yu.F.;. AN Ukrainskoj SSR, Kiev (Ukrainian SSR). Inst. Teoreticheskoj Fiziki. 1988. 29p. (In Russian). Order Number DE90611035. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

BF-10568.

Applications of the classical theory of group invariants to the construction of effective Hamiltonians (EH) for various nuclear, molecular etc. systems are discussed. The EH has the form of a power series of fundamental invariants. The latter ones are expressed in terms of the generators of symmetry group G. The proprties of a generating function firts introduced by E.Th. Molien are described. The methods of calculating these functions allow us to find the total number of fundamental invariants, the order of each invariant and their structure for any arbitrary finite group of semisimple Lie group G. 26 refs.

8721 **Measurement of A and A_{nn} in elastic *pp* at 18.5 GeV/c.** Peaslee, D.C. (University of Michigan and University of Maryland, College Park, MD 20742 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 119-122 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

Measurements of A and A_{nn} are reported for 8 $p^2_\perp$ values from 1.40 to 3.35 $(GeV/c)^2$. Both show pronounced dips in this region: A at ~3.0 and A_{nn} at 42.3 $(GeV/c)^2$. It is remarked that we have no current model for associating these dips, and that a significant comparison might first be available from extensive plots of A and A_{nn} against p_{lab} and $p^2_\perp$.

8722 **Where is the proton's spin?.** Close, F.E. (Oak Ridge National Laboratory, Oak Ridge, TN 37831-6373 (US)—University of Tennessee, Knoxville, TN 37996-1200 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 169-176 (1 May 1989). DOE Contract AC05-84OR21400. (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

There has been much recent excitement arising from the claim by the EMC collaboration that none of the proton's spin is carried by quarks. There are many textbooks, including those written by some members of this audience, which assert that the proton's spin is carried by quarks. I will review the history of deep inelastic scattering of polarized leptons from polarized protons, culminating in this most recent dramatic claim. I will show that, for the last decade, data have appeared consistent with predictions of the quark model and highlight what the new and potentially exciting data are. I will conclude with suggestions for the future.

8723 **Muon anomalous magnetic moment.** Hughes, V.W. (Yale University, New Haven, CT 06520 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 326-348 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

This article presented at the Eighth International Symposium on High-Energy Spin Physics in Minneapolis, Minnesota (Sept. 12–17, 1988), describes the experiments conducted at CERN, Novosibirsk, and Brookhaven AGS to measure the muon anomolous magnetic moment.

8724 **Magnetic moments of the hyperons: A short experimental review.** Lach, J. (Fermilab, Batavia, IL (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 353-360 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

The advent of high energy hyperon beams, the discovery that hyperons produced by the interaction of high energy protons are polarized, and the realization that this polarization vector can be readily precessed to yield their magnetic moments has allowed us to test quark models of the baryons to an astonishing level of sophistication. This has all happened in the last dozen years. Let me review where these measurements are now and what the future directions might be.

8725 **Preliminary results from E756 on the Ξ^- and Ω^- magnetic moments.** Johns, K. (Physics Department, University of Minnesota, Minneapolis, MN 55455 (US)); Duryea, J.; Guglielmo, G.; Heller, K.; Shupe, M.; Thorne, K.; James, C.; Luk, K.B.; Rameika, R.; Ho, P.M.; and others. *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 374-383 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

We have used the spin precession technique to measure the Ξ^- and Ω^- magnetic moments. The preliminary results are $\mu(\Xi^-)=-0.64\pm0.02$ nuclear magnetons and $\mu(\Omega^-)=-2.0\pm0.2$ nuclear magnetons where the error for both measurements is statistical. The polarization of Ξ^-'s produced at 2.5 mr by 800 GeV protons on a Be target was 11% while the polarization of Ω^-'s was consistent with zero. Polarized Ξ^-'s and Ω^-'s were produced using spin transfer from a polarized neutral hyperon beam. The Ω^- polarization at 325 GeV/c was 6.5%.

8726 **Spin and polarization studies of weak decays.** Rudaz, S. (School of Physics and Astronomy, University of Minnesota, Minneapolis, MN 55455 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 390-407 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

This article aims at summarizing the contributions to the "Weak Decays" Technical Session of the SPIN 88 Symposium, as well as informally providing some simple theoretical background in order to place them in a broader context. Topic, covered include the weak decays of hyperons as well as exclusive semileptonic decays of B mesons.

8727 **Search for CP violation using hyperons at Fermilab.** Luk, K.B. (MS 122, Fermilab, Batavia, IL 60510 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 522-526 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

Recently there is renewal of interest in searching for CP violation in hyperon decays. The current effort at Fermilab is concentrated on measuring the difference between the decay parameters, α, of the Ξ and anti-Ξ hyperons produced by 800 GeV protons. Experiments E621, with a sample of neutral Ξ hyperons, and E756, using charged Ξ hyperons, will reach a sensitivity of the order of 10^{-2} or better. In order to search for CP violation in the hyperon sector down to the 10^{-4} level, a dedicated experiment is called for. It is conceivable that such an experiment could be done at the Fermilab

anti-proton accumulator ring. The other alternative is to perform this experiment at a high energy beam line. The merits and disadvantages of these schemes are discussed.

8728 **Spin models of the proton.** Ramsey, G.P. (Physics Department, Loyola University of Chicago, Chicago, IL 60626 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA)*, 187(1): 786-801 (1 May 1989). DOE Contract W-31-109-ENG-38. (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

We have constructed a model of the proton spin based on a broken SU(6) parametrization for the spin-weighted valence quark distributions in a longitudinally polarized proton. The polarized sea and gluon distributions are assumed to have simple relations to the corresponding unpolarized structure functions. The sum rules, which involve the non-singlet components of the structure function xg_1, imply that the valence quarks carry about 78% of the proton spin, while the spin carried by sea quarks is negative. Recent EMC data suggest a m odel in which the sea quarks carry a large negative polarization, whereas certain theoretical arguments favor a model with a smaller negatively polarized sea. These models are discussed with reference to the sum rules. Experiments are suggested which will discriminate between these models.

6454 Field Theory

Refer also to citation(s) 8647, 8648, 8717, 8823

8729 (FNAL/C–89/237-T) **The theory of hybrid stochastic algorithms.** Kennedy, A.D. (Florida State Univ., Tallahassee, FL (USA). Supercomputer Computations Research Inst.). Fermi National Accelerator Lab., Batavia, IL (USA); Florida State Univ., Tallahassee, FL (USA). Supercomputer Computations Research Inst. 21 Nov 1989. 26p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH03000;FC05-85ER25000. (CONF-8908189–1: Workshop on probabilistic methods in quantum field theory and quantum gravity, Cargese (France), 21-27 Aug 1989; FSU-SCRI–89-147). Order Number DE90003941. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

These lectures introduce the family of Hybrid Stochastic Algorithms for performing Monte Carlo calculations in Quantum Field Theory. After explaining the basic concepts of Monte Carlo integration we discuss the properties of Markov processes and one particularly useful example of them: the Metropolis algorithm. Building upon this framework we consider the Hybrid and Langevin algorithms from the viewpcint that they are approximate versions of the Hybrid Monte Carlo method; and thus we are led to consider Molecular Dynamics using the Leapfrog algorithm. The lectures conclude by reviewing recent progress in these areas, explaining higher-order integration schemes, the asymptotic large-volume behaviour of the various algorithms, and some simple exact results obtained by applying them to free field theory. It is attempted throughout to give simple yet correct proofs of the various results encountered. 38 refs.

8730 (IC–89/282) **Quantum gravity corrections from multiloop superstring scattering amplitudes.** Iengo, R. (International School of Advanced Studies, Trieste (Italy)). International Atomic Energy Agency, Vienna (Austria). Aug 1989. 7p. Sponsored by United Nations. (CONF-8906255–1: 6. Adriatic meeting on particle physics, Dubrovnik (Yugoslavia), 12-22 Jun 1989). Order Number DE90003441. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI.

We describe an evaluation of quantum correction terms to the gravitational interaction at large distance based on a 2-loop contribution to the scattering amplitude in Superstring Theory. We also explain that some Infrared Divergence previously found is an apparent one, due to a high energy approximation. 10 refs.

8731 (INIS-mf–11523) **Extensions of conformal symmetry in two-dimensional quantum field theory.** Schoutens, C.J.M. Rijksuniversiteit Utrecht (Netherlands). 24 May 1989. 128p. Order Number DE90705972. Available from NTIS (US Sales Only), PC A07/MF A01 - OSTI.

Conformal symmetry extensions in a two-dimensional quantum field theory are the main theme of the work presented in this thesis. After a brief exposition of the formalism for conformal field theory, the motivation for studying extended symmetries in conformal field theory is presented in some detail. Supersymmetric extensions of conformal symmetry are introduced. An overview of the algebraic superconformal symmetry is given. The relevance of higher-spin bosonic extensions of the Virasoro algebra in relation to the classification program for so-called rational conformal theories is explained. The construction of a large class of bosonic extended algebras, the so-called Casimir algebras, are presented. The representation theory of these algebras is discussed and a large class of new unitary models is identified. The superspace formalism for O(N)-extended superconformal quantum field theory is presented. It is shown that such theories exist for $N \leq 4$. Special attention is paid to the case $N = 4$ and it is shown that the allowed central charges are $c(n_+n_-) = 6n_+n_-/(n_+n_-)$, where n_+ and n_- are positive integers. A different class of so(N)-extended superconformal algebras is analyzed. The representation theory is studied and it is established that certain free field theories provide realizations of the algebras with level $S = 1$. Finally the so-called BRST construction for extended conformal algebras is considered. A nilpotent BRST charge is constructed for a large class of algebras, which contains quadratically nonlinear algebras that fall outside the traditional class if finitely generated Lie (super)algebras. The results are especially relevant for the construction of string models based on extended conformal symmetry. 118 refs., 7 tabs.

8732 (IYaF–88-113) **Fractional topological charge and torons in supersymmetric $O(3)_{sigma}$-model and in gauge theories.** Zhitnitskij, A.R.;. AN SSSR, Novosibirsk (USSR). Inst. Yadernoj Fiziki. 1988. 13p. Order Number DE90611018. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

MN-08455.

The new class of self-dual solutions with a fractional topological number in the 2d Q(3) sigma-model and 4d SUSY gluodynamics (SYM) is considered. The corresponding contribution to fermion condensate (psi-barpsi) has finite nonzero value. 16 refs.; 5 figs.

8733 (IYaF–88-125) **A new way of instanton-antiinstanton interaction description: The nonlinear O(3)-sigma model example.** Sil'vestrov, P.G.;. AN SSSR, Novosibirsk (USSR). Inst. Yadernoj Fiziki. 1988. 30p. Order Number DE90611019. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

MN-08445.

To find the instanton-antiinstanton potential a method of calculation of the functional integral near the configurations, which are only approximate solutions of equation of motion, is developed. The collective coordinates are chosen for only that modes which can't be integrated in Gauss approximation. Instanton-antiinstanton pair is a name for a configuration minimizing the action in all other undangerous directions. As a practical example the asymptotic of pseudoparticle interaction in nonlinear O(3)-sigma model is found. 21 refs.; 1 fig.

8734 (KFKI–1989-32/A) **Quark model and QCD.** Anisovich, V.V. (AN SSSR, Leningrad (USSR). Inst. Yadernoj Fiziki);. Hungarian Academy of Sciences, Budapest (Hungary). Central Research Inst. for Physics. Jun 1989. 24p. Order Number DE90611021. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

Using the language of the quarks and gluons for description of the soft hadron physics it is necessary to take into account two characteristic phenomena which prevent one from usage of QCD Lagrangian in the straightforward way, chiral symmetry breaking, and confinement of colour particles. The topics discussed in this context are: QCD in the domain of soft processes, phenomenological Lagrangian for soft processes and exotic mesons, spectroscopy of low-lying hadrons (mesons, baryons and mesons with heavy quarks - c,b -), confinement forces, spectral integration over quark masses. (author) 3 refs.; 19 figs.; 3 tabs.

8735 (LBL–27475) **Exotic signatures from supersymmetry.** Hall, L.J. (California Univ., Berkeley, CA (USA). Dept. of Physics);. Lawrence Berkeley Lab., CA (USA). Aug 1989. 16p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00098. (UCB-PTH–89/16;CONF-8907177–1: Ettore Majorana international

school of subnuclear physics, Erice (Italy), 26 Jul - 3 aug 1989). Order Number DE90004034. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Minor changes to the standard supersymmetric model, such as soft flavor violation and R parity violation, cause large changes in the signatures. The origin of these changes and the resulting signatures are discussed. 15 refs., 7 figs., 2 tabs.

8736 (NIKHEF-H-89-7) **Operator algebra from fusion rules: The infinite number of Ising theories.** Fuchs, J. Nationaal Inst. voor Kernfysica en Hoge-Energiefysica (NIKHEF), Amsterdam (Netherlands). Sectie H. Mar 1989. 27p. Order Number DE90705951. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI.

It is described how the fusion rules of a conformal field theory can be employed to derive differential equations for the four-point functions of the theory, and thus to determine eventually the operator product coefficients for primary fields. The results are applied to the Ising fusion rules. A set of theories possessing these function rules is found which is labeled by two discrete parameters. For a specific value of one of the parameters, these are the level one Spin(2m + 1) Wess-Zusimo-Witten theories; it is shown that they represent an infinite number of inequivalent theories. 38 refs.

8737 (RRK-89-17) **BRS current and related anomalies in two-dimensional gravity and string theories.** Fujikawa, Kazuo; Inagaki, Takeshi; Suzuki, Hiroshi. Hiroshima Univ., Takehara (Japan). Research Inst. for Theoretical Physics. Jun 1989. 38p. Order Number DE90733095. Available from NTIS (US Sales Only), PC A03/MF A01.

The BRS currents in two-dimensional gravity and supergravity theories, which are related to string theory, contain anomalous terms. The origin of these anomalies can be neatly understood in a carefully defined path integral. We present the detailed calculations of these BRS and related anomalies in the holomorphic or antiholomorphic sector separately in the conformal gauge. One-loop renormalization of the Liouville action becomes transparent in our formulation. We identify a BRS-invariant BRS current (and thus nilpotent charge) and a conformally invariant ghost number current by incorporating the dynamical Weyl freedom explicitly. The formal path integral construction of various composite operators is also checked by using the operator product technique. Implications of these BRS analyses on possible non-critical string theories at d<26 or d<10 are briefly discussed. (author).

8738 (RRK-89-18) **Thermal partition function of non-critical bosonic strings.** Suzuki, Hiroshi. Hiroshima Univ., Takehara (Japan). Research Inst. for Theoretical Physics. Jun 1989. 10p. Order Number DE90733097. Available from NTIS (US Sales Only), PC A02/MF A01.

The thermal free energy of free non-critical bosonic strings in a D-dimensional space-time is examined. By integrating (or summing) over the Weyl freedom, the free energy and the one-loop vacuum amplitude are modular invariant for any D < 26. Thus the (background) Weyl invariance is realized. In the case of L yields infinity, where L is the compactification radius of the Weyl mode, the physical spectrum circulating in the loop becomes continuous. A connection between this continuous spectrum and the unitarity of string perturbation theory is briefly mentioned. (author).

8739 **Integrability, conformal symmetry, and noncritical Virasoro algebras.** Thacker, H.B. (Fermi National Accelerator Lab., Batavia, IL (USA)); Itoyama, H. *Nuclear Physics [Section] B (Netherlands),* 5A: 9-14 (Sep 1988). (CONF-8803248--: 3. University of California conference on statistical mechanics, Davis, CA (USA), 27-30 Mar 1988).

We discuss the relation between integrability and conformal symmetry in the context of a unitary c = 1 lattice Virasoro algebra for the noncritical eight-vertex model. The lattice algebra is related to the critical conformal algebra by a modular transformation in spectral parameter (rapidity) space. Virasoro generators for massive free fermions are explicitly constructed in terms of integrals of local densities and a connection with higher conservation laws is exhibited. Comparing the Verma module states of the noncritical algebra with the Bethe ansatz states, we discuss a connection between the FQS discrete sequence and the bound state spectrum of the eight-vertex/massive-Thirring/sine-Gordon model. (orig.).

8740 **Renormalizability of the functional Schroedinger picture in Robertson–Walker space-time.** Eboli, O. (Center for Theoretical Physics, Laboratory for Nuclear Science and Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139 (US)); Pi, S.; Samiullah, M. *Annals of Physics (New York) (USA),* 193(1): 102-141 (Jul 1989).

We study free and self-interacting scalar quantum field theories in a flat Robertson-Walker metric in the functional Schroedinger picture. We discuss Schroedinger picture quantization, relating it to conventional Heisenberg picture quantization. For the interacting theory, we introduce the time-dependent Gaussian approximation to study time evolution of pure and mixed states and we establish renormalizability of the approximation. We also study the question of computing a finite, renormalized energy-momentum tensor for both the free and the interacting theory in the Gaussian appproximation. Using the adiabatic expansion, we show that the entire subtration necessary to make the the energy-momentum tensor finite in the free theory can be written in terms of covariantly conserved tensors. We further show that the same subtraction is sufficient to make the energy-momentum tensor finite in the Gaussian approximation for the interacting theory provided that the mass and coupling constants are renromalized. © 1989 Academic Press, Inc.

8741 **Does pure SU(2) gauge theory confine?.** Cahill, K. (Argonne National Lab., IL (USA). High Energy Physics Div.). *Physics Letters [Section] B (Netherlands),* 231(3): 294-298 (9 Nov 1989). DOE Contract W-31109-ENG-38;FG04-84ER40166.

Noncompact simulations of pure SU(2) without gauge fixing on a 10^4 lattice are consistent with perturbation theory at very weak coupling but show no evidence of quark confinement at strong coupling. (orig.).

8742 **Off-shell Ward identities and gauge symmetries in string theory.** Porrati, M. (California Univ., Berkeley (USA). Dept. of Physics). *Physics Letters [Section] B (Netherlands),* 231(4): 403-407 (16 Nov 1989). DOE Contract AC03-76SF00098. Grant PHY-85-1585.

I describe a new method of obtaining gauge-symmetry transformation laws for the effective lagrangian of an arbitrary string theory. The method applies to exact as well as spontaneously broken gauge symmetries. The transformation laws, exact to all orders in alpha' are determined inductively in the number of fields by the corresponding off-shell Ward identities. The case of broken supersymmetry is examined in some detail. (orig.).

8743 **Topological phase entanglements of membrane solitons in division algebra sigma models with a Hopf term.** Chia-Hsiung Tze (Institute of High Energy Physics, Physics Department, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061 (US)); Nam, S. *Annals of Physics (New York) (USA),* 193(2): 419-471 (1 Aug 1989).

Exploiting the unique connection between the division algebras of the complex numbers (C), quaternions (H), octonions (Ω) and the essential Hopf maps $S^{2n-1} \to S^n$ with n=2, 4, 8, we study S^{n-2}-membrane solitons in three D-dimensional KP(1) σ-models with a Hopf term, (D, K)=(3, C), (7, H), and (15, Ω). We present a comprehensive analysis of their topological phase entanglements. Extending Polyakov's approach to Fermi–Bose transmutations to higher dimensions, we detail a geometric regularization of Gauss' linking coefficient, its connections to the self-linking, twisting, writhing numbers of the Feynman paths of the solitons in their thin membrane limit. Alternative forms of the Hopf invariant show the latter as an Aharono–Bohm–Berry phase of topologically massive, rank (n−1) antisymmetric tensor U(1) gauge fields coupled to the S^{n-2}-membranes. Via a K-bundle formulation of the dynamics of electrically and magnetically charged extended objects these phases are shown to induce a dyon-like structure on these membranes. We briefly discuss the connections to harmonic mappings, higher dimensional monopoles and instantons. We point out the relevance of the Gauss–Bonnet–Chern theorem on the connection between spin and statistics. By way of the topology of the infinite groups of sphere mappings $S^n \to Sn$, n=2, 4, 8, we also analyze

the implications of the Hopf phase on the fractional spin and statistics of the membranes. © 1989 Academic Press, Inc.

8744 **Chern-Simons terms in four-dimensional heterotic string theory.** Das, A. (Department of Physics and Astronomy, University of Rochester, Rochester, New York 14627 (US)); Maharana, J.; Roy, S. *Physical Review [Section] D: Particles and Fields (USA),* 40(8): 2636-2640 (15 Oct 1989). DOE Contract AC02-76ER13065.

We consider a four-dimensional heterotic string theory whose massless states are the *N*=4 supergravity multiplet and the gauge multiplet of SO(44). The string is coupled to the gauge background maintaining the world-sheet supersymmetry. It is found that the non-Abelian gauge current conservation becomes anomalous at the quantum level. The anomalies, however, can be eliminated by requiring the antisymmetric tensor field to transform nontrivially under the gauge transformation. This, in turn, introduces a Chern-Simons term in the definition of the corresponding field strength for it to be gauge invariant.

8745 **Comment on "Chiral gauge theories on a lattice and application to the chiral Schwinger model".** Golterman, M.F.L. (Department of Physics, The University of California at Los Angeles, Los Angeles, California 90024-1547 (US)); Petcher, D.N. *Physical Review [Section] D: Particles and Fields (USA),* 40(8): 2727-2728 (15 Oct 1989).

The action proposed by Aoki for treating fermions on the lattice coupled chirally to gauge fields is shown to generate mass terms for the gauge fields. Thus this model when treated consistently is identical to the model proposed by Smit.

8746 **Reply to "Comment on 'Chiral gauge theories on a lattice and application to the chiral Schwinger model' ".** Aoki, S. (Physics Department, Brookhaven National Laboratory, Upton, New York 11973 (US)). *Physical Review [Section] D: Particles and Fields (USA),* 40(8): 2729-2730 (15 Oct 1989). DOE Contract AC02-76CH00016.

In the preceding paper by Golterman and Petcher, from the consistency of the theory, it is claimed that the lattice action I proposed for chiral gauge theories is equivalent to the model proposed by others before. Here I discuss differences between the two formalisms in detail. The possibility of a nonperturbative continuum limit is also mentioned.

8747 **Quark-number susceptibility in quenched quantum chromodynamics.** Gavai, R.V. (Theory Division, European Organization for Nuclear Research (CERN), CH-1211 Geneve 23, Switzerland (XC)); Potvin, J.; Sanielevici, S. *Physical Review [Section] D: Particles and Fields (USA),* 40(8): 2743-2746 (15 Oct 1989).

Using staggered fermions, we measure the quark-number susceptibility of quenched quantum chromodynamics in a Monte Carlo simulation on an $8^3 \times 4$ lattice. At low temperatures it is consistent with zero and it rises suddenly to nonzero values across the known deconfinement phase transition. Implications for the interpretation of this susceptibility as an indicator of the presence of light baryonic modes in the plasma are discussed.

8748 **Maximum quasiparticle velocity in nonrelativistic quantum field theories.** Bolsterli, M. (T Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545 (US));. *Physical Review [Section] A: General Physics (USA),* 40(9): 5455-5457 (1 Nov 1989).

It is shown that the fermion quasiparticle in many nonrelativistic quantum field theories has a maximum velocity.

65 PHYSICS II

6510 Nuclear Physics

Refer also to citation(s) 7557, 7558, 7559, 8781

8749 (CONF-8808198–5) **Q^2 and A dependence of Δ(1232) electroexcitation in nuclei.** Sealock, R.M. Virginia Univ., Charlottesville, VA (USA). Inst. of Nuclear and Particle Physics. [1989]. 14p. Sponsored by U.S. DOE Energy Research. DOE Contract FG05-89ER40501. From Excited baryons conference; Troy, NY (USA); 4-6 Aug 1988. Order Number DE90003470. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Inclusive electron scattering measurements from SLAC of Δ electroexcitation in nuclei are presented. Electrons with energies of 0.96, 1.1, 1.3 and 1.5 GeV were scattered from H, ^{4}He, C, Fe and W at 37.5° and detected with the End Station A 1.6 GeV/c spectrometer. Q^2 at the Δ peak ranged from 0.2 to 0.5 (GeV/c^2). For all nuclear targets the Δ peak position shifts for higher invariant mass as Q^2 increases and in all but one case is above that of the free nucleon. Cross sections have been fitted by the form $\sigma = cA^b$. For the Δ region b varies from 0.99 to 1.02 with uncertainties of ±0.01. For the dip region A dependence is observed that is consistent with the effects of Fermi broadening of the quasielastic and Δ peaks. Transverse form factors have been calculated and fitted by the function $1/(1 + Q^2/\Lambda^2)$. The Λ and invariant mass dependences of Λ are discussed. 22 refs., 6 figs., 1 tab.

8750 (DOE/ER/40408–1) **[Deexcitation processes in nuclear reactions]: Progress report.** Purdue Univ., Lafayette, IN (USA). [1989]. 17p. Sponsored by U.S. DOE Energy Research. DOE Contract FG02-88ER40408. Order Number DE90004170. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

During the past year, the major effort of our group has been Fermilab experiment E735, Search for the Quark-Gluon Plasma in $p\bar{p}$ Collisions at $\sqrt{s}$ = 1.8 TeV. We have also made considerable progress in the study of the mass-yield distribution and momentum transfer in intermediate energy heavy ion reactions as well as in a similar study of the interaction of silver with 15 GeV/nucleon oxygen ions. These experiments have been described in detail in the 1987 three-year proposal. 15 refs., 6 figs.

8751 (GSI–89-65(prepr.)) **Transactinide elements.** Armbruster, P. Gesellschaft fuer Schwerionenforschung m.b.H., Darmstadt (Germany, F.R.). Aug 1989. 22p. (CONF-890826–: International nuclear physics conference, Sao Paulo (Brazil), 20-26 Aug 1989). Available from Available from Gesellschaft fuer Schwerionenforschung m.b.H., Darmstadt (Germany, F.R.).

In this report the progress in our understanding of transactinide (Z > 104) elements is reviewed. New experimental data and recent calculations allow to reconsider the question of shell-stabilized elements, the Superheavies. Nuclear structure aspects of the heaviest nuclei and insights into the amalgamation process of two heavy nuclei both combined give a better comprehension why inspite of a world-wide effort during the last 20 years no elements beyond 109 were discovered, and why the elements below 110 became accessible by reactions using Pb- and Bi-targets. The experiments discussed here were done by our research group, the 'SHIPPERS', at GSI, Darmstadt, in the period 1981-1988, the calculations presented were performed by different theoretical groups collaborating during the last years closely with our laboratory. (orig.).

8752 (LA–11711-M) **A nuclear cross section data handbook.** Fisher, H.O.M. Los Alamos National Lab., NM (USA). Dec 1989. 277p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-36. Order Number DE90004990. Available from NTIS, PC A13/MF A01 - OSTI; GPO Dep.

Isotopic information, reaction data, data availability, heating numbers, and evaluation information are given for 129 neutron cross-section evaluations, which are the source of the default cross sections for the Monte Carlo code MCNP. Additionally, pie diagrams for each nuclide displaying the percent contribution of a given reaction to the total cross section are given at 14 MeV, 1 MeV, and thermal energy. Other information about the evaluations and their availability in continuous-energy, discrete-reaction, and multigroup forms is provided. The evaluations come from ENDF/B-V, ENDL85, and the Los Alamos Applied Nuclear Science Group T-2. Graphs of all neutron and photon production cross-section reactions for these nuclides have been categorized and plotted. 21 refs., 5 tabs.

8753 (LBL–27725) **A database of fragmentation cross section measurements applicable to cosmic ray propagation calculations.** Crawford, H.J. (California Univ., Berkeley, CA (USA). Space Sciences Lab.); Engelage, J.; Jones, F.C.; Guzik, T.G.; Mitchell, J.W.; Wefel, J.P.; Waddington, C.J.; Webber, W.R.; Soutoul, A.; Ferrando, P.; Lindstrom, P.J. Lawrence Berkeley Lab.,

CA (USA). Aug 1989. 6p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00098. (CONF-900122–5: 21. international cosmic ray conference, Adalaide (Australia), 6-19 Jan 1990). Order Number DE90002683. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

A database of single particle inclusive fragment production cross section measurements has been established and is accessible over common computer networks. These measurements have been obtained from both published literature and direct communication with experimenters and include cross sections for nuclear beams on H, He, and heavier targets, and for H and He beams on nuclear targets, for energies >30 MeV/nucleon. These cross sections are directly applicable to calculations involving cosmic ray nuclear interactions with matter. The data base includes projectile, target, and fragment specifications, beam energy, cross section with uncertainty, literature reference, and comment code. It is continuously updated to assure accuracy and completeness. Also available are widely used semi-empirical formulations for calculating production cross sections and excitation functions. In this paper we discuss the database in detail and describe how it can be accessed. We compare the measurements with semi-empirical calculations and point out areas where improved calculations and further cross section measurements are required. 5 refs., 2 figs.

6511 Experimental Techniques

Refer also to citation(s) 8713, 8771

8754 (ORNL/FTR–3479) **[The nucleus at high spin]: Foreign trip report, October 17–November 4, 1989.** Johnson, N.R.; Baktash, C; Lee, I-Yang. Oak Ridge National Lab., TN (USA). 17 Nov 1989. 20p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90003593. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The travelers attended the symposium of the workshop on "Nuclear Structure in the Era of New Spectroscopy, Part B: The Nucleus at High Spin," that was held at the Niels Bohr Institute (NBI) in Copenhagen, Denmark. They gave a total of five presentations that covered various aspects of the nuclear spectroscopy research at ORNL. In addition, one of the travelers (C.B.) attended the first week of "Part C: Nuclear Physics with Large Arrays," of the same workshop, where he discussed the heavy-ion transfer work at the HHIRF. The travelers visited the Tandem Accelerator Laboratory of the Niels Bohr Institute at Roskilde, Denmark, where they discussed plans for new instrumentation developments and research activities of mutual interest.

6512 Nuclear Properties and Reactions, A = 1-5, Experimental

Refer also to citation(s) 8695, 8696

8755 Polarized proton and antiproton experiments at Fermilab E-581/704. Yokosawa, A. (Argonne National Laboratory, Argonne, IL 60439 (US)). E-704 Collaboration. *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 210-221 (1 May 1989). DOE Contract W-31-109-ENG-38. (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

We summarize activities concerning the Fermilab polarized beams. They include a description of the polarized-beam facility, measurements of beam polarization by polarimeters, asymmetry measurements in the π^0 production at large x, and experiments with polarized beams during the next fixed-target period.

8756 Measurement of parity nonconservation in proton-deuteron scattering at 43 MeV. Kystrin, S. (Institut fuer Mittelenergiephysik, ETH, CH-8093 Zurich, Switzerland (CH)); Lang, J.; Liechti, J.; Luscher, H.; Maier, T.; Muller, R.; Simonius, M.; Smyrski, J.; Sromicki, J.; Haeberli, W.; and others. *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 469-473 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

Parity nonconservation has been studied in the interaction of longitudinally polarized protons with deuterons at 43 MeV. Protons from pd elastic scattering and from part of the pd breakup spectrum were detected in the angular range 24°–61° (laboratory frame). The longitudinal analyzing power is found to be $(+0.4\pm0.7)\cdot10^{-7}$.

8757 Narrow structure in the analyzing power of the $^3He(\vec{p},d)X$ reaction at 0.8 GeV. Gazzaly, M.M. (University of Minnesota, Minneapolis, MN 55455 (US)); Barlett, M.; Hoffmann, G.W.; Garfagnini, R.; Jones, K.; Tanaka, N.; Nasser, M.A.; Pauletta, G.; Santi, L.; Smith, C.; Whitney, R. *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 641-648 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

The analyzing power A_y has been measured for the $^3He(\vec{p},d)X$ reaction at a deuteron angle of 22° (lab.) and a proton energy of 0.8 GeV. Narrow resonances in the missing mass dependence of A_y were observed. The resonance energies appear to agree with previous cross section data and with energies predicted by theoretical models.

8758 Anomalous spin response in the $^4He(\vec{p},\vec{p}')^4He^*$ reaction at 500 MeV. Nanda, S.K. (C.E.B.A.F., Newport News, VA 23606 (US)); Sterbenz, S.M.; Dehnhard, D.; Jones, M.K.; Parman, C.E.; Yen, Yi-Fen; Jones, K.W. *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 681-683 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

Spin-flip probabilities, S_{nn}, larger than the free nucleon-nucleon values were observed in the $^4He(\vec{p},\vec{p}')^4He^*$ reaction at T_p=500 MeV and q=375 MeV/c. The results differ from previous measurements on other nuclei.

8759 Search for a T=2 dibaryon. Parker, B. (Northwestern University, Evanston, Illinois 60208 (US)); Seth, K.K.; Ginsburg, C.M.; O'Reilly, B.; Sarmiento, M.; Soundranayagam, R.; Trokenheim, S. *Physical Review Letters (USA),* 63(15): 1570-1573 (9 Oct 1989).

We have made a good-resolution, high-sensitivity search for a T=2 dibaryon in the missing-mass spectra for the reaction $d(\pi^-,\pi^+)\pi^-nn$ at 292 MeV. Our results are consistent with there being no resonance peak due to such a state in the mass region 2001–2070 MeV. 95%-confidence upper limits for the integrated cross sections for such a state are presented. It is found that a quasifree model calculation, without final-state interactions, considerably underpredicts the continuum yield in the vicinity of the threshold.

6513 Nuclear Properties and Reactions, A = 6-19, Experimental

Refer also to citation(s) 8692

8760 Measurement of the ratio of Σ^0/Λ inclusive production and the Σ^0 and Λ polarizations by 28.5 GeV/C protons on beryllium. Dukes, E.C. (University of Michigan, Ann Arbor, MI 48109 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 58-65 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

The ratio of the cross section for Σ^0 inclusive production to the cross section for Λ inclusive production has been measured with 28.5 GeV/c protons incident on a beryllium target. The ratio does not depend strongly on the momentum of the produced particle between 10 and 24 GeV/c and is $0.278\pm0.011\pm0.050$, where the uncertainties are statistical and systematic in that order. The polarization of the Σ^0 has been measured with the same data and is found to be opposite to that of the Λ. The polarization of the Λ has also been measured in the transverse momentum range $0.64<p_T<1.14$ GeV/c and is consistent with previous results.

8761 Polarization and spin transfer of Ω^- and Ξ^- hyperons at 800 GeV. Longo, M.J. (University of Michigan (US)); Border, P.; Ho, P.M.; Heller, K.; Duryea, J.; Guglielmo, G.; Johns, K.; Shupe,

M.; Thorne, K.; James, C.; and others. *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 80-88 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

Fermilab experiment E756 has measured the polarization of W^- hyperons produced by 800 GeV protons to be small compared to that of Ξ^- hyperons. When produced by a neutral beam containing polarized Λ and Ξ^0 hyperons, both the Ω^- and the Ξ^- have a significant polarization indicating a large spin transfer at high energies.

8762 **Analyzing power in inclusive π^0 production at high x_F with 185 GeV/c polarized proton and antiproton beams.** Nessi-Tedaldi, F. (Rice University, Houston, TX 77251 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 89-98 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

We present first results for the analyzing power A_N in inclusive π^0 production obtained using the new 185 GeV/c Fermilab polarized proton and antiproton beams. We obtain a value $A_N(p\rightarrow\pi^0)=0.10\pm0.03$ in the kinematic region $0.2<x_F<0.8$ and $0.3<p_T<1.2$ GeV/c. An interpretation of this result using a simple parton recombination model suggests that the spin of the proton is carried by its valence quarks.

8763 **Spin parameter measurements in inclusive Λ, Σ^0, K_S and $\bar{\Lambda}$ production.** Nessi, M. (Rice University, Houston, TX 77251 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 66-79 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

We have measured the spin parameters *P*, *A*, and *D* in the inclusive Λ and Σ^0 production at 13.3 and 18.5 GeV/c. Our data cover a region of moderate p_T and Feynman *x* up to 0.75. The measured effects for *A* and *D* are generally smaller than predictions based on a simple parton-recombination model. We present here an expansion of such a model. We present here an expansion of such a model which introduces a finite transversity spin-flip amplitude.

8764 **Parity violation in electron scattering from carbon: A progress report.** Dodson, G.W. (Massachusetts Institute of Technology, Cambridge, MA 02139 (US)); Dow, K.A.; Farkhondeh, M.; Flanz, J.; Isakovich, K.; Kowalski, S.; Sargent, C.P.; Turchinetz, W.; Kim, D.; Kumar, K.S.; and others. *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 486-492 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

An experiment is being performed at the MIT Bates Linear Accelerator Center to measure the parity-violating asymmetry in the elastic scattering of longitudinally polarized electrons from Carbon. The asymmetry, which is due to the isoscalar component of the neutral weak current, is predicted to be about 0.6×10^{-6}. We have recently obtained preliminary data with polarized electrons. The status of the experiment is discussed.

6514 Nuclear Properties and Reactions, A = 20-38, Experimental

Refer also to citation(s) 8772

6515 Nuclear Properties and Reactions, A = 39-58, Experimental

Refer also to citation(s) 8626

8765 (LBL–27672) **Cosmic ray half life of ^{54}Mn.** Norman, E.B.; Sur, B.; Vogel, K.R.; Lesko, K.T.; Larimer, R.M.; Browne, E. Lawrence Berkeley Lab., CA (USA). Aug 1989. 3p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00098. (CONF-900129–1: 21. international cosmic ray conference, Adelaide (Australia), 6-19 Jan 1990). Order Number DE90000134. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

A search for the β^+ decay of ^{54}Mn has established an upper limit of 4.4×10^{-8} for this branching ratio, and a lower limit of 13.3 for the log ft value for this second forbidden unique transition. Assuming that the β^- decay branch has the same log ft value, then its partial half life must be greater than 4×10^4 years. Experiments to directly measure the β^- decay rate of ^{54}Mn are now in progress. 6 refs., 2 figs.

6516 Nuclear Properties and Reactions, A = 59-89, Experimental

8766 (ORNL/TM–11404) **Preliminary cross sections for gamma rays produced by interaction of 1 to 40 MeV neutrons with ^{59}Co.** Slusarchyk, T.E. Oak Ridge National Lab., TN (USA). 15 Oct 1989. 27p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004393. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Data for 46 distinct gamma rays previously obtained at the 20-meter station of the Oak Ridge Electron Linear Accelerator (ORELA) were studied to determine cross sections for 1.0-40.0 MeV neutron interactions with ^{59}Co. Data reduction methods and preliminary cross sections are given in this report. 5 refs., 12 figs., 8 tabs.

6517 Nuclear Properties and Reactions, A = 90-149, Experimental

Refer also to citation(s) 8749

8767 (LBL–27654) **Lower limit for the average angular momentum leading to fusion.** DiGregorio, D.E. (Comision Nacional de Energia Atomica, Buenos Aires (Argentina)); Lesko, K.T.; Harmon, B.A.; Norman, E.B.; Pouliot, J.; Sur, B.; Chan, Y.D.; Stokstad, R.G. Lawrence Berkeley Lab., CA (USA). Oct 1989. 5p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00098. (CONF-8908129–4: 12. workshop on nuclear physics, Iguazu Falls (Argentina), 28 Aug - 1 sep 1989). Order Number DE90004027. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

The existence of a finite and essentially energy-independent lower limit for the average angular momentum leading to fusion at energies well below the Coulomb barrier has been experimentally confirmed. We report the observation of this angular momentum limit for the systems ^{12}C + ^{128}Te, ^{7}Li + ^{133}Cs, and ^{3}He + ^{136}Ba. We find that the predicted values of $\bar{l}$ are consistent with experiment. The expected variation of $\bar{l}$ with entrance channel is also observed. 3 refs., 2 figs.

8768 **Deformation and shape coexistence of 0^+ states in ^{98}Sr and ^{100}Zr.** Mach, H. (Brookhaven National Lab., Upton, NY (USA)); Moszynski, M.; Gill, R.L.; Wohn, F.K.; Winger, J.A.; Hill, J.C.; Molnar, G.; Sistemich, K. *Physics Letters [Section] B (Netherlands),* 230(1/2): 21-26 (26 Oct 1989). DOE Contract AC02-76CH00016;W-7405-ENG-82.

Half-lives of 2_1^+ levels [2.80(8) ns in ^{98}Sr, 0.55(2) ns in ^{100}Zr] and the ^{98}Sr 4_1^+ level [80(6) ps] were obtained using a β-γ-γ triple coincidence system. Analysis of B(E2) and B(E0) rates indicates that ^{98}Sr and ^{100}Zr have very similar structures. Both have a highly deformed ($\beta \simeq 0.4$) yrast band and a moderately deformed (vertical strokeβvertical stroke $\simeq$ 0.2) low-lying band. The highly deformed bands in ^{98}Sr and ^{100}Zr are nearly identical to the yrast bands in ^{100}Sr and ^{102}Zr. (orig.).

8769 **Tests of time reversal in neutron-nucleus scattering.** Bowman, J.D. (Los Alamos National Laboratory, Los Alamos, NM 87544 (US)). *AIP Conference Proceedings (American Institute of Physics) Conference Proceedings (USA),* 187(1): 501-507 (1 May 1989). (CONF-880983–: 8. international symposium on high energy spin physics, Minneapolis, MN (USA), 12-17 Sep 1988).

Experiments to test time-reversal invariance are discussed. The experiments are based on observables constructed from the momentum and spin vectors of epithermal neutrons and from the spin of an aligned or polarized target. It is shown that the proposed tests are detailed balance tests of time-reversal invariance. The status of the experiments is briefly reviewed.

8770 **Search for neutrinoless double-β decay of ^{100}Mo.** Alston-Garnjost, M. (Physics Division, Lawrence Berkeley Laboratory, 1 Cyclotron Road, University of California, Berkeley, Berkeley, California 94720 (US)); Dougherty, B.L.; Kenney, R.W.; Tripp, R.D.; Krivicich, J.M.; Nicholson, H.W.; Sutton, C.S.; Dieterl *Physical Review Letters (USA)*, 63(16): 1671-1673 (16 Oct 1989). DOE Contract FG03-86ER40271.

We report the results of an experimental search for neutrinoless double-β decay using isotopically enriched foils of ^{100}Mo interleaved in a stack of 40 silicon detectors. With an exposure of 69.9 mole days, we place lower half-life limits on the $J^{\pi}=0^{+}\rightarrow 0^{+}$ transition of 4×10^{21} yr (68% C.L.) and on the $0^{+}\rightarrow 2^{+}$ transition of 4×10^{20} yr (68% C.L.).

6519 Nuclear Properties and Reactions, A = 190-219, Experimental

8771 (BNL–43440) **Are hadron spectra thermal in 14.6 A·GeV/c nucleus-nucleus collisions?.** Hansen, O. (Kernfysisch Versneller Inst., Groningen (Netherlands)). Brookhaven National Lab., Upton, NY (USA). [1989]. 13p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-8908173–3: 6. Nordic meeting on nuclear physics, Kopervik (Norway), 10-15 Aug 1989). Order Number DE90004150. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Data on spectra and yields of pions and kaons from central Si + Au interactions of 14.6 GeV/c per nucleon are presented. The results are discussed in terms of a thermal one source model. 5 refs., 4 figs.

8772 (CONF-900147–1) **Heavy ion inelastic scattering with a 4π gamma detector.** Gross, E.E. Oak Ridge National Lab., TN (USA). [1989]. 10p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. From 13. symposium on nuclear physics; Oaxtepec (Mexico); 3-6 Jan 1990. Order Number DE90002709. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Heavy-ion inelastic scattering with a new technique that uses a 4π γ-ray detector in coincidence with charged particle detectors is applied to ^{24}Mg(200 MeV) + ^{208}Pb scattering. In addition to differential cross sections, a complete particle-γ angular correlation is obtained for decay of the 2_1^+ (1.37 MeV) state of ^{24}Mg. The data are analyzed in coupled-channels. The correlation data proves to be especially sensitive to the static quadrupole moment. 14 refs., 9 figs.

8773 (LBL–27926) **Ultrarelativistic nucleus-nucleus collisions at CERN: The NA35 experiment.** Odyniec, G. The NA35 Collaboration. Lawrence Berkeley Lab., CA (USA). Oct 1989. 46p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00098. (CONF-8908148–3: International workshop on relativistic aspects of nuclear physics, Rio de Janeiro (Brazil), 28-31 Aug 1989). Order Number DE90004033. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The aim of the NA-35 experiment is to study nuclear matter under extreme conditions. Evidence that conditions reached in 60 GeV/N and 200 GeV/N relativistic heavy ion collisions are adequate for the formation of a quark-gluon plasma where color would no longer be confined to hadronic dimensions is presented. Future plans for experiments in 1990–1991 with ^{32}S beams and 1993 and up with Pb beams at the SPS are discussed. 26 refs., 23 figs., 3 tabs.

8774 **Fission in intermediate energy heavy ion reactions.** Wilhelmy, J.B. (Los Alamos National Lab., NM (USA)); Begemann-Blaich, M.; Blaich, T.; Boissevain, J.; Fowler, M.M.; Gavron, A.; Jacak, B.V.; Lysaght, P.S.; Britt, H.C.; Fields, D.J. *Nuclear Physics [Section] A (Netherlands)*, 502: 502 (9 Oct 1989). DOE Contract W-7405-ENG-36. (CONF-890491–: International conference on fifty years of research in nuclear fission, Berlin (Germany, F.R.), 3-7 Apr 1989).

A systematic study of reaction mechanisms at intermediate energies (50-100 MeV/A) has been performed at the Lawrence Berkeley Laboratory's BeValac using medium weight projectiles on medium and heavy element targets. A gas and plastic phoswich detector system was employed which gave large geometric coverage and a wide dynamic response. The particles identified with the gas detectors could be characterized into three components - intermediate mass fragments (IMF), fission fragments (FF) and heavy residues (HR). Major observed features are: The reaction yields are similar in the 50 to 100 MeV/A range, central collisions have high multiplicty of IMF's with broad angular correlations consistent with a large participant region, effects of final state Coulomb interactions are observed and give information on the size and temporal behavior of the source, true fission yields are dependent on target fissility and correlated with relatively peripheral collisions. Analysis of fission and evaporation yields implies limiting conditions for which fission decay remains a viable deexcitation channel. (orig.).

6520 Nuclear Properties and Reactions, A = 220 and Above, Experimental

8775 (INIS-SU–132/A) **Photonuclear data: Evaluated cross sections for sup 235,238U photofission.** Varlamov, V.V.; Efimkin, N.G.; Surgutanov, V.V.; Khoronenko, A.A.; Chernyaev, A.P. Moskovskij Gosudarstvennyj Univ., Moscow (USSR); Moskovskij Gosudarstvennyj Univ., Moscow (USSR). Kafedra Neorganicheskoj Khimii. 1987. 39p. (In Russian, English). Order Number DE90610728. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The review comprises data on experimental works dealing with the investigation of ^{235,238}U nuclei photofission, results of analysis and evaluation of energy dependences of photofission reaction cross sections in γ-quanta energy range of 3-100 MeV.

8776 (NEA-CRP-L–302(Rev.)) **Data for decay Heat Predictions: Proceedings of a specialists' meeting.** Nuclear Energy Agency, 75 - Paris (France). 1987. 386p. (CONF-8709122–: Specialists' meeting on data for decay heat predictions, Studsvik (Sweden), 7-10 Sep 1987; NEANDC–245-U). Order Number DE90610729. Available from NTIS (US Sales Only), PC A17/MF A01 - OSTI; INIS.

These proceedings of a specialists' meeting on data for decay heat predictions are based on fission products yields, on delayed neutrons and on comparative evaluations on evaluated and experimental data for thermal and fast fission. Fourteen conferences were analysed.

8777 **Spontaneous fission properties and lifetime systematics.** Hoffman, D.C. (California Univ., Berkeley (USA). Dept. of Chemistry). *Nuclear Physics [Section] A (Netherlands)*, 502: 502 (9 Oct 1989). DOE Contract AC03-76SF00098. (CONF-890491–: International conference on fifty years of research in nuclear fission, Berlin (Germany, F.R.), 3-7 Apr 1989).

Half-lives for spontaneous fission of nuclides with even and odd numbers of particles are compared with recent theoretical calculations. A summary of odd particle hindrance factors is given. The most recent measurements of kinetic-energy and mass distributions and neutron emission for spontaneous fission of the heaviest nuclides are summarized and discussed. (orig.).

6530 Nuclear Theory

Refer also to citation(s) 8632, 8700, 8712, 8748, 8750, 8776

8778 (CONF-8908129–3) **Quasi-elastic processes at low energies and their influence on other reaction modes.** Rehm, K.E. Argonne National Lab., IL (USA). [1989]. 21p. Sponsored by U.S. DOE Energy Research. DOE Contract W-31109-ENG-38. From 12. workshop on nuclear physics; Iguazu Falls (Argentina); 28 Aug - 1 sep 1989. Order Number DE90003796. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Quasi-elastic reactions induced by medium-weight projectiles (A=28-80) were measured with good particle resolution using an Enge Split Pole Magnetic Spectrograph. The cross sections for these processes are considerably larger than the ones observed in similar light-ion-induced reactions. The influence of quasi-elastic processes on other reaction modes is discussed. It is found that strong correlations between the various types of reaction exist, requiring a consistent coupled-channels treatment of all reaction modes involved. 46 refs., 14 figs.

8779 (CONF-8911150–1) **Calculations of the ground state of ^{16}O.** Pieper, S.C. Argonne National Lab., IL (USA). [1989]. 9p. Sponsored by U.S. DOE Energy Research. DOE Contract W-31109-ENG-38. From 6. international conference on recent progress in many body theories; Arad (Israel); 6-10 Nov 1989. Order Number DE90003558. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

One of the central problems in nuclear physics is the description of nuclei as systems of nucleons interacting via realistic potentials. There are two main aspects of this problem: specification of the Hamiltonian, and calculation of the ground states of nuclei with the given interaction. Realistic interactions must contain both two- and three-nucleon potentials and these potentials have a complicated non-central operator structure consisting, for example, of spin, isospin and tensor dependences. This structure results in formidable many-body problems in the computation of the ground states of nuclei. At present, reliable solutions of the Faddeev equations for the A = 3 nuclei with such interactions are routine. Recently, Carlson has made an essentially exact GFMC calculation of the He ground state using just a two-nucleon interaction, and there are reliable variational calculations for more complete potential models. Nuclear matter calculations can also be made with reasonable reliability. However, there have been very few calculations of nuclei with A > 5 using realistic interactions, and none with a modern three-nucleon interaction. In the present paper I present a new technique for variational calculations for such nuclei and apply it to the ground state of ^{16}O. 15 refs., 2 figs., 3 tabs.

8780 (LBL–27983) **Rotational population patterns and searches for the nuclear SQUID [Superconducting Quantum Interference Device].** Canto, L.F. (Universidade Federal, Rio de Janeiro, RJ (Brazil). Inst. de Fisica); Donangelo, R.J.; Farhan, A.R.; Guidry, M.W.; Rasmussen, J.O.; Ring, P.; Stoyer, M.A. Lawrence Berkeley Lab., CA (USA). Nov 1989. 29p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-76SF00098. (CONF-890902–21: 198. American Chemical Society national meeting, Miami, FL (USA), 10-15 Sep 1989). Order Number DE90004032. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

This paper presents new theoretical results for rotational population patterns in the nuclear SQUID effect. (The term nuclear SQUID is in analogy to the solid-state Superconducting Quantum Interference Devices.) The SQUID effect is an interesting new twist to an old quest to understand Coriolis anti-pairing (CAP) effects in nuclear rotational bands. Two-neutron transfer reaction cross sections among high-spin states have long been touted as more specific CAP probes than other nuclear properties. Heavy projectiles like Sn or Pb generally are recommended to pump the deformed nucleus to as high spin as possible for transfer. The interference and sign reversal of 2n transfer amplitudes at high spin, as predicted in the early SQUID work imposes the difficult requirement of Coulomb pumping to near back-bending spins at closest approach. For Pb on rare earths we find a dramatic departure from sudden-approximation, so that the population depression occurs as low as final spin 10h. 14 refs., 8 figs.

8781 (ORNL/TM–11372) **Maxwellian cascade model.** Macklin, R.L. Oak Ridge National Lab., TN (USA). Nov 1989. 24p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004389. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

A model for gamma-ray cascade de-excitation of a nucleus derived from the Maxwellian energy distribution function but imposing energy conservation was investigated. Energy distributions and multiplicities and their averages were found over a range of nuclear temperatures and excitation energies appropriate to neutron capture. The model was compared to existing measurements for tantalum, a case where the level density was high and thus a good approximation to the model. 7 refs., 13 figs.

8782 **On the production and spectroscopy of Sigma hypernuclei.** Dover, C.B. (Brookhaven National Lab., Upton, NY (USA)); Millener, D.J.; Gal, A. *Physics Reports: A Review Section of Physics Letters (Section C) (Netherlands),* 184(1): 1-97 (Dec 1989). DOE Contract AC02-76CH00016.

The production mechanisms and the spectroscopy of Sigma hypernuclei are critically examined, with a view towards understanding the data on the interactions of the Sigma with nucleons (N) and nuclei in a consistent framework. Data from Sigma$^-$ atoms and quasi-free Sigma production in the K^-,$pi^\pm$ reactions are used to derive information on the Sigma-nucleus well depth. Starting from several parametrizations of the SigmaN effective interaction V_{SigmaN} in the nucleus, we perform a series of shell model calculations of the energy spectrum of the p-shell Sigma hypernuclei. The models for V_{SigmaN} are motivated by successful one-boson exchange (OBE) descriptions of the free space SigmaN scattering data. Certain levels of the Sigma hypernucleus reflect the coherent energy shifts due to the strong spin and isospin dependence of V_{SigmaN}. We isolate optimum experimental cases for the study of such coherent effects as well as other components of V_{SigmaN}, for instance the spin-orbit part. If the single-particle Sigma-nucleus potential is indeed deep enough to support a spectrum of quasi-stable states, which is not clear experimentally, their width in some cases depends sensitively on the isospin purity and the degree of configuration mixing induced by V_{SigmaN}. The production cross sections of selected Sigma hypernuclear states in the (K^-,$pi^\pm$) reactions are estimated in distorted wave Born approximation (DWBA); these are also sensitive to deviations of the wave functions from pure isospin and/or j-j coupling limits. On the basis of our results, we suggest several experiments which may resolve some of the open questions concerning the SigmaN and Sigma-nucleus interactions. (orig.) With 140 refs.

8783 **The pion-nucleus resonance and nuclear translucence.** Gibbs, W.R. (Los Alamos National Lab. (LANL), NM (USA). Theoretical Div.); Kaufmann, W.B.; Dedonder, J.P. *Physics Letters [Section] B (Netherlands),* 231(1/2): 6-10 (2 Nov 1989).

We point out that the apparent transparency recently seen in several low-energy pion interactions with nuclei can be related to pion-nucleus bound states. This feature arises from a pion-nucleus resonance: The positive energy along of such a bound state. Experiments for the further investigation of this phenomenon are discussed. (orig.).

8784 **Relative yields, conservation laws, and Coulomb energy in medium-energy heavy-ion collisions.** De Angelis, A.R. (Rutgers - the State Univ., New Brunswick, NJ (USA). Dept. of Physics and Astronomy); Mekjian, A.Z.; Fai, G. *Physics Letters [Section] B (Netherlands),* 231(1/2): 1-5 (2 Nov 1989). DOE Contract FG02-86ER40251. Grant PHY-87-0159.

We use a model of medium-energy heavy-ion collisions based on the principle of minimum information to calculate relative yield from heavy-ion collisions. The model allows for the formation of excited fragments and uses a mean-field prescription for the Coulomb interaction among fragments. We find that the yields are strongly temperature dependent and that most important factors in determining this dependence are conservation of baryon number and charge, and the intrinsic excitation energy of the fragments. We do not find it necessary to include the Coulomb energy in order to produce a minimum in the yields. (orig.).

8785 **Use of Monte Carlo techniques to derive yields for n+^{12}C multibody breakup reactions: Programming the computer to simulate collisions by fast neutrons.** Dickens, J.K. (Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831-6356 (US)). *Computers in Physics (USA),* 3(6): 62-68 (Nov 1989). DOE Contract AC05-84OR21400.

A computer "experiment" using Monte Carlo sampling methods has been designed to simulate the breaking up of ^{12}C by medium-energy neutrons into final reaction channels having 2, 3, or 4 outgoing charged particles. The calculational nuclear physics concept used in the "experiment" is one of a sequentially decaying, highly excited compound nucleus. Two methods of Monte Carlo sampling, the rejection method and the cumulative-distribution method, are discussed as applied to probability functions developed in the program.

8786 **Nuclear fission: What have we learned in 50 years?.** Vandenbosch, R. (Washington Univ., Seattle (USA). Dept. of Chemistry). *Nuclear Physics [Section] A (Netherlands),* 502: 502 (9 Oct 1989). (CONF-890491–: International conference on fifty years of research in nuclear fission, Berlin (Germany, F.R.), 3-7 Apr 1989).

After a brief summary of the early paper of Bohr and Wheeler, our current understanding of the probability for fission, the deformation energy surface, the dynamics of the descent from saddle to scission, and mass distributions is developed. (orig.).

8787 Resonance structure in the fission of (^{235}U+n). Moore, M.S. (Los Alamos National Lab. (LANL), NM (USA). Physics Div.); Leal, L.C.; De Saussure, G.; Perez, R.B.; Larson, N.M. *Nuclear Physics [Section] A (Netherlands),* 502: 502 (9 Oct 1989). (CONF-890491–: International conference on fifty years of research in nuclear fission, Berlin (Germany, F.R.), 3-7 Apr 1989).

A new multilevel reduced R-matrix analysis of the neutron-induced resonance cross sections of ^{235}U has been carried out. We used as a constraint in the analysis the angular anisotropy measurements of Pattenden and Postma, obtaining a Bohr-channel (or J, K channel) representation of the resonances in a two-fission vector space for each spin state. Hambsch et al., have reported definitive measurements of the mass- and kinetic-energy distributions of fission fragments of (^{235}U+n) in the resonance region and analyzed their results according to the fission-channel representation of Brosa et al., extracting relative contributions of the two asymmetric and one symmetric Brosa fission channels. We have explored the connection between Bohr-channel and asymmetric Brosa-channel representations. The results suggest that a simple rotation of coordinates in channel space may be the only transformation required; the multilevel fit to the total and partial cross sections is invariant to such a transformation. (orig.).

8788 Short-range correlations and the intermittency phenomenon in multihadron rapidity distributions. Carruthers, P. (University of Arizona, Physics Department, Tucson, Arizona 85721 (US)); Sarcevic, I. *Physical Review Letters (USA),* 63(15): 1562-1565 (9 Oct 1989).

We show that the increase of bin-averaged factorial moments with decreasing size of the rapidity bin δy (the so-called "intermittency" phenomenon) can be understood on the basis of conventional short-range correlations and a simple linked-pair *Ansatz* for higher-order correlations.

8789 Nucleus as a color filter in QCD: Hadron production in nuclei. Brodsky, S.J. (Stanford Linear Accelerator Center, Stanford University, Stanford, California 94309 (US)); Hoyer, P. *Physical Review Letters (USA),* 63(15): 1566-1569 (9 Oct 1989). DOE Contract AC03-76SF00515.

The data on hadron production in nuclei exhibit two striking regularities which are not readily explained by conventional hadron dynamics: (1) The mass-number dependence $A^{\alpha(x_F)}$ of inclusive production cross sections has a universal power $\alpha(x_F)$, which is independent of the produced hadron. (2) The A dependence of J/ψ production in nuclei has two distinct components: an A^1 contribution at low x_F and an anomalous $A^{2/3}$ contribution which dominates at large x_F. We show that both phenomena can be understood in QCD as a consequence of the nucleus filtering out small, color-singlet Fock-state components of the incident-hadron wave function.

8790 Neutron multiple scattering and absorption factors. Johnson, E. (Chemistry Division, Oak Ridge National Laboratory, P. O. Box 2008, Oak Ridge, Tennessee 37831-6375 (US)); Robinson, L. *Review of Scientific Instruments (USA),* 60(11): 3447-3451 (Nov 1989). DOE Contract AC05-84OR21400.

Absorption and multiple scattering factors for neutrons are determined using the Monte Carlo integration method. This procedure gives results that are as accurate as that from other methods. It is also simpler and apparently converges more rapidly than other methods.

6540 Radiation and Shielding Physics

Refer also to citation(s) 7557, 7558, 7559, 8966

8791 (RAL–89-067) **Quantum effects in deep inelastic neutron scattering.** Mayers, J.;. Rutherford Appleton Lab., Chilton (UK). Jul 1989. 35p. Order Number DE90611498. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

In the Impulse Approximation (IA), which is used to interpret deep inelastic neutron scattering (DINS) measurements, it is assumed both that the target system can be treated as a gas of free atoms and that the struck atom recoils freely after the collision with the neutron. Departures from the IA are generally attributed to final state effects (FSE), which are due to the inaccuracy of the latter assumption. However it is shown that even when FSE are neglected, significant departures from the IA occur at low temperatures due to inaccuracies in the former assumption. These are referred to as initial state effects (ISE) and are due to the quantum nature of the initial state. Comparison with experimental data and exactly soluble models shows that ISE largely account for observed asymmetries and peak shifts in the neutron scattering function S(q,omega), compared with the IA prediction. It is shown that when FSE are neglected, ISE can also be neglected when either the momentum transfer or the temperature is high. Finally it is shown that FSE should be negligible at high momentum transfers in systems other than quantum fluids and that therefore in this regime the IA is reached in such systems. (author).

8792 (RAL–89-068) **Deep inelastic scattering: photon and neutron complementary techniques.** Holt, R.; Mayers, J.;. Rutherford Appleton Lab., Chilton (UK). Jul 1989. 26p. Order Number DE90611499. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The development of pulsed neutron sources for inelastic scattering has revitalised interest in the study of atomic momentum distributions in condensed matter. The experimental techniques currently employed are briefly reviewed together with the complementary methods used to study electron momentum distributions using inelastic photon (Compton) scattering. Both the experimental and theoretical developments are compared and contrasted and the future of neutron 'Compton' scattering briefly outlined. (author).

8793 Many-electron effects on transport processes in dense helium. Younger, S.M. (A-Division, Lawrence Livermore National Laboratory, Livermore, California 94550 (US)); Harrison, A.K.; Sugiyama, G.;. *Physical Review [Section] A: General Physics (USA),* 40(9): 5256-5272 (1 Nov 1989). DOE Contract W-7405-ENG-48.

Many-electron effects on dynamical correlations in dense helium are studied by means of self-consistent-field molecular dynamics, a computational method that combines a Hartree-Fock solution of the electronic structure of an arbitrary collection of atoms with molecular dynamics. Pair correlation functions, velocity autocorrelation functions, and coefficients of self-diffusion are calculated for helium at densities between 0.1 and 1.5 g/cm^3 and at temperatures of 1 and 5 eV. Comparisons are made to results computed with semiempirical pair potentials derived from low- and high-density experimental data. With increasing density, the self-consistent-field molecular-dynamics results progressively diverge from the results of molecular-dynamics simulations using Hartree-Fock pair potentials, reflecting the onset of many-atom screening effects within local clusters of atoms. This dynamic screening results in a 30% increase in the diffusion coefficient over that obtained in a molecular-dynamics simulation employing pair interaction potentials.

6550 Medical Physics

8794 (AERE-R–13536) **A software package for monitoring radiation level.** Ghani, S.N. (Newcastle upon Tyne Polytechnic (UK));. UKAEA Harwell Lab. (UK). Nuclear Physics and Instrumentation Div. Jun 1989. 30p. Available from Available from H.M. Stationery Office, London, price Pound 10.00.

This report describes a software suite of four files which run on a 68000 based computer running under the OS-9 operating system. A real-time expert system STIMULUS is used for gathering data from remote environmental radiation monitors and alerting responsible personnel when an exceptional situation is detected. The advantage of using STIMULUS is that any number of sophisticated and complex rules for data collection, interpretation and actions can be easily introduced without any modification to the associated C-language programmes. (author).

8795 (ENEA-RT-DISP–89-4) **Report on activity and measurements of surveillance carried out by the national observatory.** Ariete, M.G. (ENEA, Rome (Italy). Direzione Sicurezza Nucleare e Protezione Sanitaria); Belvisi, M.; Calicchia, R.;

Fiorenza, R.; Onori, L.; Tamarchio, L. ENEA, Rome (Italy). 1989. 77p. (In Italian). Order Number DE90610872. Available from NTIS (US Sales Only), PC A05/MF A01 - OSTI; INIS.

As a consequence of the Chernobyl accident a general radiometric survey of Italian territory was established. To this scope a very extensive program of environmental sampling, measurements, data collection, processing and management of this was carried out. All laboratories of nuclear centers, universities and local public health units, involved in this survey, had a unique aim: the radiological analysis to determine environmental contamination levels or to estimate preliminary population doses, finalized on short term, urgent protective mesures, and on long term, in addition to protective measures and for environmental studies. ENEA DISP, which is equipped by hardware and software instrumentation of its Emergency Center, was responsable for technical preparedness of the program. A National Observatory has been created for determing Cs134, Cs137 and Sr90 level on environmental and food samples on defined locality. The first part of this report presents the type, the frequency and localities where sample was collected. The second part presents the trend of the radioactive contamination on all foodstaffs, as data collected by each laboratory and in term of National mean concentration level. 77 figs.

8796 (NEANDC(E)–292-U-Vol.III-Euratom) **Annual progress report on nuclear data 1987.** Hansen, H.H. (ed.). Nuclear Energy Agency, 75 - Paris (France). Nuclear Data Committee. Oct 1988. 57p. (INDC-EUR–022-G). Order Number DE90610931. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

In 1987 the efforts for the improvement of the set of standard neutron cross-sections, the mass-distributions in the fission of U^{235} continued. In the field of nuclear data for fission technology, effort was concentrated on subthermal neutron energy, Cr isotopes and Ni isotopes. In the area of nuclear data for fusion technology, data for neutron transport calculations in the blanket were improved. The radionuclide metrology works determined decay-scheme data and preparation of standards. A cooperation was established between INDC and CBNM for neutron flux metrology.

8797 (NIRS-R–16, pp. 110-119) **Studies on dosimetry for internally deposited alpha-emitters.** Ishigure, Nobuhito (National Inst. of Radiological Sciences, Chiba (Japan)); Sekiguchi, Masamichi; Nakano, Takashi; Matsuoka, Osamu. National Inst. of Radiological Sciences, Chiba (Japan). Mar 1989. (In Japanese). In *Final report on the project research 'stochastic effects of irradiation and risk estimation': April 1983 - March 1988.* Order Number DE90710149. Available from NTIS (US Sales Only), PC A08/MF A01.

Dosimetry of internal exposure, in any cases, begins with the determination of the deposition and retention pattern of internally deposited radioactive elements. From a methodological point of view in this context, the following three subjects have been studied: (1) calculation of calibration coefficient of Pu lung monitor using Monte-Carlo simulation; (2) development of Pu in vivo counting device for small experimental animals; (3) development of autoradiography of alpha-emitters using a solid state nuclear track detector. The final goal of dosimetric study is to re-assess the dosimetric factors recommended by ICRP, such as 'the modifying factor' and 'the quality factor'. A series of study has evaluated techniques developed for macroscopically assessing the initial deposition and retention in small experimental animals. Microautoradiography using a solid state nuclear track detector would offer primary data on microdosimetry in deep lung burdened with alpha-emitters. (Namekawa, K).

6560 Condensed Matter Physics

Refer also to citation(s) 7882, 7892, 7902, 7903, 8014, 8048, 8051, 8070, 8080

8798 (BNL–43410) **Soft modes, freezing, and nonlinear response of a dipolar glass.** Lyons, K.B. (AT and T Bell Labs., Murray Hill, NJ (USA)); Fleury, P.A.; Chou, H.; Kjems, J.; Shapiro, S.; Rytz, D. Brookhaven National Lab., Upton, NY (USA). [1989]. 11p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH00016. (CONF-8907111–1: 1. USA/USSR workshop on ferroelectricity, Boulder, CO (USA), 9-14 Jul 1989). Order Number DE90003647. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

A careful study of the polarization dynamics near the dipolar glass transition, utilizing both neutron and light scattering reveals a dichotomy in the behavior, on the one hand suggesting ordered domains of macroscopic extent and on the other clearly indicating dynamic cluster behavior in the same temperature region. An examination of this evidence leads us to suggest a percolated cluster model for the dipolar glass phase in KTN. 13 refs., 4 figs., 1 tab.

8799 (INIS-SU–133/A, pp. 68-71) **Experimental study of intensive electron beam scattering in melting channel.** Balagura, V.S. (AN Ukrainskoj SSR, Kharkov (Ukrainian SSR). Fiziko-Tekhnicheskij Inst.); Kurilko, V.I.; Safronov, B.G. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

Voprosy atomnoj nauki i tekhniki.; v. 4(46).

Multiple scattering of an intensive electron beam at 28 keV energy passing through a melting channel in iron targets is experimentally studied. The dependence of scattering on the melting current value is established. The material density in the channel on the basis of the binary collision method is evaluated. It is shown that these density values are of three orders less than the estimations made on the basis of the data on energy losses of electrons in the channel. 6 refs.; 4 figs.

8800 (INIS-SU–133/A, pp. 66-67) **Hard parametric x radiation of relativistic electrons in monocrystals.** Morokhovskij, V.L. (AN Ukrainskoj SSR, Kharkov (Ukrainian SSR). Fiziko-Tekhnicheskij Inst.); Adejshvili, D.I.; Blazhevich, S.V.; Bochek, G.L.; Kulibaba, V.I.; Shramenko, V.I. Gosudarstvennyj Komitet po Ispol'zovaniyu Atomnoj Ehnergii SSSR, Moscow (USSR). 1988. (In Russian). In *Physics of radiation defects and radiation materials science. Scientific-technical collection.* Order Number DE90705983. Available from NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS.

Voprosy atomnoj nauki i tekhniki.; v. 4(46).

Hard parametric X radiation spectra of 1200 MeV electrons in a 50 μm-thick silicon crystal are experimentally studied at the radiation angle Θ_k=17.88 mrad and different crystal orientations. It is shown that the Energy dependence in the spe ctrcal density maximum of radiation intensity corresponds to the coherent bremsstrahlung kinematics, and the dependence of photon number in the coherent peak on crystal orientation has a sharp maximum at crystal orientations corresponding to the Bragg conditions for irradiated xhotons.

8801 (PNL-SA–16991) **The morphology of collision cascades as a function of recoil energy.** Heinisch, H.L. (Pacific Northwest Lab., Richland, WA (USA)); Singh, B.N. Pacific Northwest Lab., Richland, WA (USA). Sep 1989. 20p. Sponsored by U.S. DOE Energy Research. DOE Contract AC06-76RL01830. (CONF-891204–6: 4. international conference on fusion reactor materials, Kyoto (Japan), 4-8 Dec 1989). Order Number DE90004115. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

An analytical method based on defect densities has been devised to determine the threshold energies for subcascade formation in computer simulated collision cascades. Cascades generated with the binary collision code MARLOWE in Al, Cu, Ag, Au, Fe, Mo and W were analyzed to determine the threshold energy for subcascade formation, the number of subcascades per recoil per unit energy and the average spacing of subcascades. Compared on the basis of reduced damage energy, metals of the same crystal structure have subcascade thresholds at the same reduced energy. The number of subcascades per unit reduced damage energy is about the same for metals of the same crystal structure, and the average spacing of subcascades is about the same in units of lattice parameters. Comparisons between subcascade threshold energies and average recoil energies in fission and fusion neutron environments show the spectral sensitivity of the formation of subcascades.

8802 (UCRL–100614) **The concept of "axial-symmetry constraint" and its significance in recrystallization.** Price, C.W. Lawrence Livermore National Lab., CA (USA). 20 Oct 1989. 7p.

Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. (CONF-900128–2: International conference on recrystallization in metallic materials, Wollongong (Australia), 22-26 Jan 1990). Order Number DE90003620. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Grain growth and grain impingement that occur during recrystallization are simulated reasonably well with a simplified computer model that is based on a regular geometric grain growing in an impingement cell. The model also generates effective kinetic simulations, but only when the axial symmetry of the grain is constrained to the axial symmetry of the impingement cell. This condition is defined as the "axial-symmetry constraint." When the simulated grain geometry deviates from the axial-symmetry constraint, the simulated kinetic behavior shows corresponding deviation from predicted kinetic behavior. These results imply that the geometry by which recrystallized grains fill space is more important than the actual shape if recrystallized grains. The physical significance of this concept is that the geometric shape of the interface between recrystallized and unrecrystallized material is dictated by the local deformation geometry. Once grain impingement commences and clusters of contiguous recrystallized grains form, the model interface corresponds to the interface formed by the grain clusters. The simulations reveal that interfacial areas dictated by deformation geometry are significantly greater for rolling than for extrusion, and this result correlates with experimental observations that recrystallization is more rapid in rolled materials than in extruded materials for the same initial grain size and similar reductions. Since recrystallization is an interface-controlled reaction, the axial-symmetry constraint appears to be an important concept that could contribute to improved kinetic models. 17 refs., 5 figs.

8803 (UCRL–100615) **Use of computer simulations to analyze limitations of kinetic models for recrystallization.** Price, C.W. Lawrence Livermore National Lab., CA (USA). 20 Oct 1989. 7p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. (CONF-900128–1: International conference on recrystallization in metallic materials, Wollongong (Australia), 22-26 Jan 1990). Order Number DE90003618. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Only two kinetic models appear to be appropriate for recrystallization of metals and crystallization of metallic glasses: Kolmogorov-Johnson-Mehl-Avrami (KJMA) and Speich-Fisher (SF). However, much confusion prevails on the proper use of these models because their limitations are not well understood. Fortunately, computer simulations are proving to be effective for simulating kinetic behavior. In particular, a simplified computer model, which simulates a regular geometric grain growing in an impingement cell, provides kinetic simulations that agree with experimental data. The computer model isolates specific concepts that the kinetic models were formulated on, and it also simulates different time-dependent growth relations. The KJMA model is based on linear interfacial growth and uses an extended-volume concept to compensate for impingement. The computer model isolated the effect of the extended-volume concept, and it also was used to determine why some experimental data conform to KJMA kinetics while others do not. The analysis indicated that essentially linear KJMA behavior can occur in recrystallization of metals that have reached an effectively constant state of recovery or in crystallization of amorphous metals that have reached a constant state of disorder. The SF relation is based on inverse-time-dependent growth, and it is effective for recrystallization that is retarded from an initial linear rate by factors such as the simultaneous occurrence of recovery. The computer model clearly defines the limitations of the SE model. This work demonstrates that computer simulations can define the limitations of the existing kinetic models and increase our understanding of them. 24 refs., 1 fig.

8804 **Resonance energy shifts during nuclear Bragg diffraction of x rays.** Arthur, J. (Stanford Synchrotron Radiation Laboratory, Post Office Box 4349, Bin 69, Stanford, California 94309 (US)); Brown, G.S.; Brown, D.E.; Ruby, S.L. *Physical Review Letters (USA),* 63(15): 1629-1632 (9 Oct 1989).

We have observed dramatic changes in the time distribution of synchrotron x rays resonantly scattered from ^{57}Fe nuclei in a crystal of yttrium iron garnet, which depend on the deviation angle of the incident radiation from the Bragg angle. These changes are caused by small shifts in the effective energies of the hyperfine-split nuclear resonances, an effect of dynamical diffraction for the coherently excited nuclei in the crystal. The very high brightness of the synchrotron x-ray source allows this effect to be observed in a 15-min measurement.

8805 **Efficient simulation technique to compute effective properties of heterogeneous media.** Torquato, S. (Department of Mechanical and Aerospace Engineering and Department of Chemical Engineering, North Carolina State University, Raleigh, North Carolina 27695-7910 (US)); Kim, I.C. *Applied Physics Letters (USA),* 55(18): 1847-1849 (30 Oct 1989).

We present a new simulation technique to "exactly" yield effective transport properties of disordered heterogeneous media in which the transport process is governed by a steady-state diffusion equation. Hence, the algorithm, which is based upon simulating the Brownian motion of a diffusing particle, can be applied to determine the effective electrical and thermal conductivity, dielectric constant, magnetic permeability, diffusion coefficient associated with flow past fixed obstacles, and the trapping rate associated with diffusion-controlled reactions among sinks. The simulation method is shown to have a very fast execution time. The technique is illustrated by computing the trapping rate associated with diffusion-controlled reactions; it is demonstrated to have an execution time that is at least an order of magnitude faster than previous simulation methodologies.

8806 **Theory of electrical discharges initiated from a large charge spot on dielectric surfaces.** Kadish, A. (Los Alamos National Laboratory, Los Alamos, New Mexico 87545 (US)); Maier, W.B. II; Robiscoe, R.T. *Journal of Applied Physics (USA),* 66(9): 4123-4133 (1 Nov 1989).

The nonlinear dynamics of charge transport due to an electric discharge on a dielectric surface is analyzed using a transmission line model. The relation between the resistance per unit length, $\hat{R}$, and the current, I, is assumed to be given by the local arc-welder's ansatz, $\hat{R}|I|=E^*$, where E^* is a positive constant. The model predicts that a discharge initiated in the vicinity of a charge spot can propagate partway down a current channel and abruptly terminate before transporting charge to the dielectric edge. This behavior is similar to leader phenomena observed in lightning and other electrical discharges. We show that the direction of the current along the current channel is constant throughout such a discharge. The minimum voltage at the charge spot that allows charge to be transported to the dielectric edge is determined. This critical voltage V_l depends on the length l of the current channel. We show that the "average field," V_l/l, decreases as l increases. When the charge spot voltage is less than the critical voltage, we obtain upper and lower bounds for both the arc duration time and amount of charge removed from the charge spot.

8807 **Transient heat transport in solids.** Claro, F. (Facultad de Fisica, Pontificia Universidad Catolica de Chile, Casilla 6177, Santiago 22, Chile (CL)); Mahan, G.D. *Journal of Applied Physics (USA),* 66(9): 4213-4217 (1 Nov 1989).

It is shown that heat flow is severely decreased in transient phenomena, due to nonlocal effects. The case of phonon transport in a steep temperature gradient is discussed in detail for semiconductors. Fixed end temperatures and an initial heat pulse propagating in a homogeneous sample are considered as boundary conditions. The temperature profile evolves in all cases significantly slower than local theories predict.

8808 **Percolation in alloys with thermally activated diffusion.** Ouyang, H. (Division of Engineering and Applied Science 138-78, California Institute of Technology, Pasadena, California 91125 (US)); Fultz, B.;. *Journal of Applied Physics (USA),* 66(10): 4752-4755 (15 Nov 1989).

For diffusion in a real alloy, some concepts of formal percolation theory may need to be reconsidered because the "immobile" atoms are not truly immobile. Our Monte Carlo simulations of vacancy diffusion on *bcc* lattices show the existence of a relationship between the activation barrier heights for the vacancy-atom exchanges and the effective percolation threshold concentration. In the language of formal percolation theory, we have modeled this problem by varying the immobile species' barrier height from infinity to some finite value

and calculating the resulting percolation threshold. When both species of atoms have a finite mobility, however, our results can be interpreted in terms of probabilities for vacancies to escape local clusters in a fixed amount of time. We find that the dynamical behavior undergoes a marked change above and below the formal percolation threshold, but the strength of the percolating cluster is much less important than in formal percolation theory.

8809 **Exactly soluble model for antiphase boundaries in binary ordering alloys.** Chrzan, D.C. (Department of Physics, University of California, Berkeley, Berkeley, California 94720 (US)); Falicov, L.M. *Physical Review [Section] B: Condensed Matter (USA)*, 40(12): 8194-8202 (15 Oct 1989). DOE Contract AC03-76SF00098.

An *exactly soluble* model which mimics the properties of {001} antiphase boundaries in the face-centered-cubic substitutional alloys (Ising antiferromagnets) with only nearest-neighbor interactions is developed. The three-dimensional model is extended to any dimension, including one- and two-dimensional systems. For three-dimensional systems, it is proven that, in the thermodynamic limit, antiphase boundaries are unstable at all temperatures. It is postulated that antiphase boundaries are unstable for all thermodynamic systems with dimension greater than 1. In one dimension, where antiphase boundaries can be defined mathematically, the concentration of antiphase boundaries is 1/2 at both zero and infinite temperatures, but at all temperatures in between, the concentration is less than 1/2. Antiphase boundaries are found at equilibrium in higher-dimensional systems with small sizes, the order of those used in Monte Carlo simulations of the Ising model. The implications of this unusual size effect are discussed.

8810 **Theory of optical spectra in a magnetic field in doped semiconductor quantum wells: Impurity-induced broadening and transitions.** Lyo, S.K. (Sandia National Laboratories, Albuquerque, New Mexico 87185 (US)). *Physical Review [Section] B: Condensed Matter (USA)*, 40(12): 8418-8424 (15 Oct 1989). DOE Contract AC04-76DP00789.

The effect of carrier-impurity interactions on luminescence- and excitation-spectroscopy line shapes and the Landau-level spectral density in a strong quantizing magnetic field is examined in modulation-doped semiconductor quantum wells. The line-shape function is obtained by summing the "ladder diagrams," extending our previous "one-rung" approximation. Apart from yielding a line broadening, the carrier-impurity interaction is found to induce off-diagonal transitions (ODT) ($n \rightarrow n'$; $n' \neq n$) between the Landau levels in the conduction and valence bands, breaking the usual $n \rightarrow n$ selection rule. Here the first and second integers indicate the Landau quantum numbers in the conduction (valence) and valence (conduction) bands, respectively, for luminescence (excitation), for example, in an *n*-type system. The Landau-level spectral density (essential for obtaining the line-shape functions) is investigated by a self-consistent Born approximation which includes inter-Landau-level impurity scattering. The theory is applied to an *n*-type strained $In_xGa_{1-x}As/GaAs$ quantum well, where optical transitions arise between the conduction band and the strain-split in-plane "light-hole" band. For excitation spectra, the theory predicts that ODT introduce lines below the usual $n_F \rightarrow n_F$ threshold transition as well as satellite lines between the usual main $n \rightarrow n$ lines above the threshold (i.e., $n \geq n_F$). Here n_F is the quantum number of the lowest-lying empty or partially filled conduction-band Landau level. The luminescence line shape is dominated by ODT 1, 2,...$\rightarrow$0 (in addition to the main 0$\rightarrow$0 transition) at low temperatures and by the usual $n \rightarrow n$ transitions at high temperatures.

8811 **Low-temperature properties of the Hubbard chain with an attractive interaction.** Lee, K. (Department of Physics, Temple University, Philadelphia, Pennsylvania 19122 (US)); Schlottmann, P.;. *Physical Review [Section] B: Condensed Matter (USA)*, 40(13): 9104-9112 (1 Nov 1989).

The thermodynamic Bethe-ansatz equations for the one-dimensional Hubbard model with attractive on-site interaction of the electrons are solved numerically at low temperatures. At low temperatures the dominant states consist of spin-paired electrons (Cooper-pair–like) and excitations of such pairs (without breaking up the singlet bound states). A critical field (energy required to depair a Cooper pair) is obtained at T=0 (note that the superconducting T_c=0), which disappears for $T \neq 0$. The specific heat is linear in temperature, and the dependence of the coefficient γ on band filling and magnetic field is discussed. The excitation spectrum shows some analogies with that of resonant valence bonds in two dimensions.

6561 Superconductivity

Refer also to citation(s) 7994, 7996, 8020, 8037, 8041, 8043, 8044, 8045, 8050, 8655

8812 **The federal maze.** Timmer, W.C. (Argonne National Lab., IL (USA)). *Superconductor Industry (USA)*, 1(2): 20-27 (1988).

This article discusses U.S. government funding for superconductivity research and development. The individual programs and goals are examined for the following departments: Department of Defense, Department of Energy, National Science Foundation, Department of Commerce, Department of the Interior, NASA, and the Department of Transportation.

8813 **Superconductivity: A brief introduction to its phenomenology and theories.** . Falicov, L.M. (California Univ., Berkeley, CA (USA). Dept. of Physics). *IEEE (Institute of Electrical and Electronics Engineers) Journal of Quantum Electronics (USA)*, 25(11): 2358-2364 (Nov 1989).

A brief introduction to the phenomenology of superconductivity is presented. It includes, the superconducting state-a discussion of the main features of superconductivity: the superconducting transition temperature, zero resistivity, the Meissner effect, the isotope effect, microwave and optical properties, and the superconducting energy gap. The Ginzburg-Landau equations are discussed. They are concerned with the concepts of coherence length, penetration depth, flux quantization, magnetic-field dependence of the energy gap, quantum interference phenomena, and the Josephson effect. A brief review of the new field of high-temperature superconductivity, its experimental facts, and current theories is included.

8814 **Critical state in disk-shaped superconductors.** Daumling, M. (Applied Superconductivity Center, University of Wisconsin-Madison, Madison, Wisconsin 53706 (US)); Larbalestier, D.C.;. *Physical Review [Section] B: Condensed Matter (USA)*, 40(13): 9350-9353 (1 Nov 1989).

We have calculated the magnetic fields and currents occurring in a disk-shaped superconductor (radius $\gg$thickness) in the critical state in a self-consistent way using finite-element analysis. We find that the field shielded (or trapped) in the center of the disk is roughly equal to $J_c d$, where d is the thickness of the disk. The shielding currents also create radial fields which are or order $J_c d/2$ on the disk surface. For low applied fields $H_{appl} < J_c d$ these self-field effects dominate, leading to a deviation of the local field direction from the applied field, which can exceed 90 deg towards the outside perimeter of the disk. If $J_c d$ is large, as is the case for $YBa_2Cu_3O_{7-\delta}$ single crystals at 4.2 K, self-field effects persist up to several telsa applied field. The field dependence of the calculated magnetic moment in the self-field dominated regime is independent of whether J_c is weakly or strongly ($\propto 1/H$) dependent on field. The calculations were validated by comparison to both magnetic and resistive measurements on a disk-shaped section in Nb_3Sn tape.

6570 Theoretical and Mathematical Physics

Refer also to citation(s) 8646, 8728

8815 (IPP–6/254) **Generalized Hamiltonians, functional integration and statistics of continuous fluids and plasmas.** Tasso, H. Max-Planck-Institut fuer Plasmaphysik, Garching (Germany, F.R.). May 1985. 27p. (CONF-8506400–: 2. international workshop on mathematical aspects of fluid and plasma dynamics (MAFPD-2), Paris (France), 24-28 Jun 1985). Order Number DE90729143. Available from NTIS (US Sales Only), PC A03/MF A01.

Generalized Hamiltonian formalism including generalized Poisson brackets and Lie-Poisson brackets is presented in Section II. Gyroviscous magnetohydrodynamics is treated as a relevant example in Euler and Clebsch variables. Section III is devoted to a short review of functional integration containing the definition and a discussion of

ambiguities and methods of evaluation. The main part of the contribution is given in Section IV, where some of the content of the previous sections is applied to Gibbs statistics of continuous fluids and plasmas. In particular, exact fluctuation spectra are calculated for relevant equations in fluids and plasmas. (orig.).

8816 (ITFA–88-53) **On the spectrum of the staggered Dirac operator at finite chemical potential.** Vink, J.C. (Amsterdam Univ. (Netherlands). Inst. voor Theoretische Fysica). NIKHEF-H-Institute Theoretical Physics Amsterdam Collaboration. Nationaal Inst. voor Kernfysica en Hoge-Energiefysica (NIKHEF), Amsterdam (Netherlands). Sectie H. Dec 1988. 33p. Order Number DE90705952. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI.

The spectrum of the staggered Dirac operator in two-dimensional QEDF is investigated at finite chemical potential. In the quenched model, it is shown that lattice artifacts cause a spurious scattering of eigenvalues. This scattering disappears when lattice distance is taken to zero. In the unquenched model, a new approach is used to show that similar effects are absent. 17 refs., 6 figs.

8817 (IYaF–88-136) **Solving physical problems with REDUCE: Nonlinear water waves. Calculation of the curvature tensor. Angular momentum addition in quantum mechanics.** Grozin, A.G.;. AN SSSR, Novosibirsk (USSR). Inst. Yadernoj Fiziki. 1988. 45p. (In Russian). Order Number DE90610995. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

MN-08557.

The preprint is the second part of the problem book on using REDUCE in physics. It contains many examples useful for the construction of programs for solving physical problems of very different nature. This part contains the problem of nonlinear water waves, the calculation of the curvature tensor and angular momentum addition. 9 refs.; 2 figs.

8818 (LA-UR–89-3375) **Analysis of nonlinear systems using ARMA [autoregressive moving average] models.** Hunter, N.F. Jr. Los Alamos National Lab., NM (USA). 1990. 8p. Sponsored by U.S. DOE Management & Administration. DOE Contract W-7405-ENG-36. (CONF-900139–2: 8. international modal analysis conference, Kissimmee, FL (USA), 29 Jan - 1 feb 1990). Order Number DE90002395. Available from NTIS, PC A02/MF A01; OSTI; INIS.

While many vibration systems exhibit primarily linear behavior, a significant percentage of the systems encountered in vibration and model testing are mildly to severely nonlinear. Analysis methods for such nonlinear systems are not yet well developed and the response of such systems is not accurately predicted by linear models. Nonlinear ARMA (autoregressive moving average) models are one method for the analysis and response prediction of nonlinear vibratory systems. In this paper we review the background of linear and nonlinear ARMA models, and illustrate the application of these models to nonlinear vibration systems. We conclude by summarizing the advantages and disadvantages of ARMA models and emphasizing prospects for future development. 14 refs., 11 figs.

8819 (LA-UR–89-3376) **Restoring force method and response estimation.** Endebrock, E.G. Los Alamos National Lab., NM (USA). [1989]. 7p. Sponsored by U.S. DOE Management & Administration. DOE Contract W-7405-ENG-36. (CONF-900139–1: 8. international modal analysis conference, Kissimmee, FL (USA), 29 Jan - 1 feb 1990). Order Number DE90002394. Available from NTIS, PC A02/MF A01; OSTI; INIS.

The restoring force method is briefly outlined. Signal modifications that are necessary to successfully determine restoring force functions are discussed and illustrated. Restoring force functions for a base and a force excited system were determined and their effectiveness demonstrated by comparing measured and predicted signals. Additional developments that would make the restoring force method more general are suggested. 5 refs., 12 figs.

8820 **Supersymmetry breaking in string-derived supergravities.** Porrati, M. (California Univ., Berkeley (USA). Dept. of Physics); Zwirner, F. *Nuclear Physics [Section] B (Netherlands),* 326(1): 162-184 (30 Oct 1989). DOE Contract AC03-76SF00098.

Classical heterotic string solutions with spontaneously broken d=4, N=1, 2 or 4 supersymmetry have been recently formulated via coordinate-dependent compactifications. We construct the corresponding low-energy effective lagrangians by means of generalized dimensional reductions a la Scherk-Schwarz. We show that these dimensional reductions of d=10, N=1 supergravity + Yang-Mills can be interpreted as special 'gaugings' of the resulting d=4, N=4 theory, characterized by a positive semidefinite potential. We also describe in detail the properties of the d=4, N=1 models obtained from the N=4 ones by a consistent Z_2xZ_2' truncation. (orig.).

8821 **Relativistic two-body models.** Polyzou, W.N. (Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242 (US)). *Annals of Physics (New York) (USA),* 193(2): 367-418 (1 Aug 1989).

A new method is introduced for constructing relativistic models of two directly interacting particles. This method includes the construction of B. Bakmjian and L. H. Thomas [*Phys. Rev.* **92** (1985), 995] and generalizations [S. N. Sokolov and Shatnii, *Teor. Mat. Fiz.* **37** (1978), 291; F. Coester and W. N. Polyzou, *Phys. Rev. D* **26** (1982), 1348], to P. A. M. Dirac's forms [*Rev. Mod. Phys.* **21** (1949), 392] of the dynamics as special cases. The new feature of this method is the way in which the theory of group representations is used to decouple the problem of adding interactions from the problem of ensuring full Poincare invariance. An analytically solvable example is given and discussed. © 1989 Academic Press, Inc.

8822 **Quantum theory of spontaneous emission and excitation near a phase-conjugating mirror.** Milonni, P.W. (Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545 (US)); Bochove, E.J.; Cook, R.J. *Journal of the Optical Society of America B: Optical Physics (USA),* 6(10): 1932-1941 (Oct 1989).

We present a quantum-electrodynamic theory of spontaneous emission in the presence of a phase-conjugating mirror (PCM) and show that the radiative relaxation rate is increased owing to the amplification of quantum noise by the PCM. For any finite value of the PCM reflectivity an atom in any initial state will relax to a steady state with a finite probability of being excited. In particular, there is a finite probability of spontaneous excitation of a ground-state atom placed near the PCM. The fluorescence spectrum of an atom near a PCM is generally described by two Lorentzian functions.

8823 **Scattering of charged particles.** Barrachina, R.O. (University of Tennessee, Knoxville, Tennessee 37996-1200 (US)); Macek, J.H. *Journal of Mathematical Physics (New York) (USA),* 30(11): 2581-2584 (Nov 1989).

Different methods of avoiding the known difficulties of the Coulomb potential scattering theory are reviewed. Mulherin and Zinnes' [J. Math. Phys. **11**, 1402 (1976)] "distorted" free waves and van Haeringen's [J. Math. Phys. **17**, 995 (1976)] Coulomb asymptotic states are considered. The equivalence of both approaches on the energy shell is shown. Actually the possibility of deriving the first method within van Haeringen's formalism by means of a distorted wave procedure is demonstrated.

8824 **Evolution of bubbles in a vacuum.** Aurilia, A. (Stanford Linear Accelerator Center, Stanford University, Stanford, California 94309 (US)); Palmer, M.; Spallucci, E. *Physical Review [Section] D: Particles and Fields (USA),* 40(8): 2511-2518 (15 Oct 1989). DOE Contract AC03-76SF00515.

This paper examines the evolution of spherical bubbles in a vacuum for all possible values of the controlling parameters within the context of the general-relativistic thin-wall approximation. We propose a general classification of the admissible solutions and a graphical-numerical algorithm for their explicit construction from any given set of initial data. The different sectors in the space of the parameters are identified and a map of regions is constructed where single families of solutions can exist.

8825 **Exact solutions to operator differential equations.** Bender, C.M. (Department of Physics, Washington University, St. Louis, Missouri 63130 (US)); Dunne, G.V. *Physical Review [Section] D: Particles and Fields (USA),* 40(8): 2739-2742 (15 Oct 1989).

This paper considers the Heisenberg equations of motion $\dot{q}=-i[q,H],\dot{p}=-i[p,H]$, for the quantum-mechanical Hamiltonian $H(p,q)$ having one degree of freedom. It is a commonly held belief that such operator differential equations are intractable. However, a

technique is presented here that allows one to obtain exact, closed-form solutions for huge classes of Hamiltonians. This technique, which is a generalization of the classical action-angle-variable methods, allows us to solve, albeit formally and implicitly, the operator differential equations of the anharmonic oscillator whose Hamiltonian is $H=p^2/2+q^4/4$.

8826 **Algorithmic randomness and physical entropy.** Zurek, W.H. (Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545 (US));. *Physical Review [Section] A: General Physics (USA)*, 40(8): 4731-4751 (15 Oct 1989).

Algorithmic randomness provides a rigorous, entropylike measure of disorder of an individual, microscopic, definite state of a physical system. It is defined by the size (in binary digits) of the shortest message specifying the microstate uniquely up to the assumed resolution. Equivalently, algorithmic randomness can be expressed as the number of bits in the smallest program for a universal computer that can reproduce the state in question (for instance, by plotting it with the assumed accuracy). In contrast to the traditional definitions of entropy, algorithmic randomness can be used to measure disorder without any recourse to probabilities. Algorithmic randomness is typically very difficult to calculate exactly but relatively easy to estimate. In large systems, probabilistic ensemble definitions of entropy (e.g., coarse-grained entropy of Gibbs and Boltzmann's entropy $H=\ln W$, as well as Shannon's information-theoretic entropy) provide accurate estimates of the algorithmic entropy of an individual system or its average value for an ensemble. One is thus able to rederive much of thermodynamics and statistical mechanics in a setting very different from the usual. *Physical entropy*, I suggest, is a sum of (i) the missing information measured by Shannon's formula and (ii) of the algorithmic information content—algorithmic randomness—present in the available data about the system. This definition of entropy is essential in describing the operation of thermodynamic engines from the viewpoint of information gathering and using systems. These Maxwell demon-type entities are capable of acquiring and processing information and therefore can "decide" on the basis of the results of their measurements and computations the best strategy for extracting energy from their surroundings. From their internal point of view the outcome of each measurement is definite.

8827 **Berry's phase and the symplectic character of quantum time evolution.** Ralston, J.P. (Department of Physics and Astronomy, University of Kansas, Lawrence, Kansas 66045 (US));. *Physical Review [Section] A: General Physics (USA)*, 40(9): 4872-4884 (1 Nov 1989).

General time-dependent, bilinear classical Lagrangian mechanics can be interpreted as a charged particle interacting with a gauge scalar and vector potential. For an arbitrary discrete number of degrees of freedom, there are enough symplectic symmetries in classical mechanics to make this system canonically identical to the most general discrete spectrum quantum system. It follows that the general invariance group of the Schroedinger system of equations is the symplectic group Sp(2*N*), not U(*N*). Several examples show the physical naturalness of the classical coordinates. In the adiabatic limit Berry's phase is identified as the cumulative change of the angle of action-angle coordinates of a normal mode. A generalization of Berry's phase, the time component of the adiabatic connection and its associated electric curvature, is shown to be on an equal footing with the usual Berry phase.

8828 **Torus structure in higher-dimensional Hamiltonian systems.** Gyorgyi, G. (Department of Physics and Engineering Physics, Stevens Institute of Technology, Hoboken, New Jersey 07030 (US)); Ling, F.H.; Schmidt, G.;. *Physical Review [Section] A: General Physics (USA)*, 40(9): 5311-5318 (1 Nov 1989).

Island tori of coupled standard maps are investigated. The study of invariants of the tangent map shows that the tori are embedded in higher-dimensional topological spheres. A new numerical method, the "quasisurface of sections" construction, reveals the torus structure in the nonlinear domain. Scaling laws and estimates for island boundaries are obtained. Arnold diffusion out of the island is found to be nonexistent or exceedingly slow. The measure of phase space occupied by islands versus that occupied by chaotic trajectories is shown to decline rapidly as the number of degrees of freedom increases.

8829 **Single-particle density matrix method for the solution of the many-electron problem.** Redondo, A. (Los Alamos National Laboratory, Los Alamos, New Mexico 87545 (US)); Marshall, J.C. *Journal of Chemical Physics (USA)*, 91(9): 5492-5499 (1 Nov 1989).

A new calculational method for the solution of the many-electron problem, the single-particle density matrix (SPDM) method, is presented. The method is based on a generalization of the Hohenberg–Kohn theorem [A. Redondo, Phys. Rev. A **39**, 4366 (1989)] which states that the ground-state energy of a many-body Hamiltonian is a universal functional of the single-particle density matrix. The calculational technique involves the minimization of the total energy, employing the methods of nonlinear programming. Using the Hartree–Fock approximation, we compare the results of the SPDM calculations with the standard diagonalization method for the molecules H_2, LiH, and N_2. Calculations are also presented in which correlation is introduced by means of the local density approximation.

8830 **Separation of classical equations of motion based on symmetry.** Banerjee, A. (Idaho National Engineering Laboratories, EG&G Idaho, Inc., Idaho Falls, Idaho 83415-2208 (US)); Adams, N.P. *Journal of Chemical Physics (USA)*, 91(9): 5444-5450 (1 Nov 1989). DOE Contract AC07-76ID01570.

We show that an invariance of a system of *N* particles simplifies the solution of the classical equations of motion.A transformation can be constructed in a straightforward manner to yield a set of active and redundant coordinates in which Hamilton's equations are separable. That is, the redundant coordinates are cyclic and the kinetic energy is block diagonal between the two sets. Furthermore, the active coordinates have properties very similar to the parent Cartesian coordinates; e.g., the derivatives of the Hamiltonian remain unchanged. The numerical application of the procedure is very straightforward; we have performed trajectories of symmetric motions of an A_2B-type molecule within the subspace of the C_{2v} configurations.

8831 **Electric curvature and the time component of the adiabatic connection.** Ralston, J.P. (Department of Physics and Astronomy, University of Kansas, Lawrence, Kansas 66045 (US));. *Physical Review [Section] A: General Physics (USA)*, 40(9): 5400-5403 (1 Nov 1989).

Generalizing the concept of the Berry phase, I show that an additional gauge structure associated with a time-component vector potential A_0 is present in the adiabatic evolution of a quantum system. The gauge structure, which generates the usual dynamical phase, is revealed by a formalism in which the time variable is treated on an equal footing with other parameters on which the Hamiltonian depends. The invariant curvature associated with A_0, an electriclike field, determines the phase difference between low- and high-energy paths in a generalized phase-space and time picture. The covariance of the Born-Oppenheimer approximation illustrates the results.

8832 **Correlations and fluctuations in reflection coefficients for coherent wave propagation in disordered scattering media.** Wang, L. (Department of Physics and the Solid State Science Center, University of California, Los Angeles, California 90024 (US)); Feng, S. *Physical Review [Section] B: Condensed Matter (USA)*, 40(12): 8284-8289 (15 Oct 1989).

The relation between the reflection coefficients and the Green's function for a coherent wave propagation in a disordered elastic-scattering medium is derived. The sum rule of the reflection and transmission coefficients corresponding to probability conservation is shown rigorously for an arbitrary scattering potential. The correlation function of the reflection coefficients is then calculated by using a Feynman-diagrammatic approach in the weak-localized multiple-scattering regime ($L \gg l \gg \lambda$). The result is in agreement with recent experiments on the so-called "memory effect" in reflection coefficients. A more general condition under which the memory effect can occur is derived. Differences between the the correlation functions for reflection and that for transmission are discussed.

70 FUSION ENERGY

Refer also to citation(s) 7462, 7668

7001 Plasma Research

Refer also to citation(s) 7034, 8206, 8208, 8230, 8652, 8653, 8814, 8944, 8945, 8946, 8947, 8950, 8956, 8959, 8960, 8963, 8967, 8977, 8979, 8984, 8988, 8993

8833 (DOE/ER/53214–1) **[Spectroscopic diagnostics of high temperature plasmas].** Moos, W. Johns Hopkins Univ., Baltimore, MD (USA). [1989]. 12p. Sponsored by U.S. DOE Energy Research. DOE Contract FG02-86ER53214. Order Number DE90003912. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

A research program in soft x-ray/ultraviolet/visible diagnostics for magnetic fusion is described. Recent results include the electron temperature, electron density and impurity densities during EML activity on the TEXT tokamak. The Zeeman effect induced circular polarization in Li neutral beam emissions has been analyzed to determine the safety factor in sawtoothing and ECRH heated discharge. The reflective properties of multilayer mirrors (10-200 Å) were measured. Future work includes an order of magnitude improvement in the time resolution of the circular-polarimeter, development of a soft x-ray normal incidence spectrometer and a feasibility study for a narrow band x-ray photometer.

8834 (GA-A–19794) **Nonlinear wave coupling and clumps in drift wave turbulence theory.** Dominguez, R.R. General Atomics, San Diego, CA (USA). Jul 1989. 9p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-89ER53277. (CONF-8903180–1: Workshop on coherent structure in plasma, Nagoya (Japan), Mar 1989). Order Number DE90004103. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Anomalous transport mediated by drift wave turbulence has been studied by many authors using weak and renormalized turbulence theory. Additional nonlinear effects coming from three-wave coupling have been studied in simple models by Waltz and for drift waves by Waltz and Dominguez. At the same time, the "clump" theory of Dupree has been extended and applied to drift wave turbulence. In the present work, we discuss how the discreteness effects associated with clumps may be combined with the nonlinear wave coupling formalism. It is shown that both the nonlinear wave coupling and clump correlation act as sources for the spectral density in k, and w, with a comparison between the two effects being presented. 5 refs.

8835 (GA-A–19803) **Initial deuterium confinement studies in DIII-D tokamak: DIII-D milestone report # 58.** DeBoo, J.C.; Schissel, D.P.; Burrell, K.; St. John, H. General Atomics, San Diego, CA (USA). Aug 1989. 12p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-89ER51114. Order Number DE90003942. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The operational space of DIII-D has been extended to include high current, high power deuterium neutral beam heating of deuterium discharges in both the single null and double null configurations. Recent completion of the neutron shielding of the DIII-D facility has allowed operation in these new parameter regimes while maintaining a low neutron dose at the site boundary. The plasma current and neutral beam power ranges with $D^0 \rightarrow D^+$ operation have been extended to $P_T \leq 12$ MW and $I_p \leq 2.5$ MA. Comparison of H-mode discharges in pure H with those in pure D indicates a continuing superior confinement in deuterium for values of $q \geq 3$; however at lower values of q the confinement becomes similar. Analysis of the energy confinement in this regime has shown no major differences in current or power scaling compared to $H^0 \rightarrow D^+$ operation. Energy confinement during the ELMing phase of $D^0 \rightarrow D^+$ H-mode discharges scales linearly with the plasma current and deteriorates with neutral beam power. Recent, ongoing time dependent analysis of discharges with long ELM-free periods following the L to H transition indicate that the energy confinement time may be independent of power so that power degradation may be a manifestation of ELMs. 1 ref., 5 figs.

8836 (INIS-mf–11517) **On the electric and magnetic field generation in expanding plasmas.** Gielen, H.J.G. Technische Univ. Eindhoven (Netherlands). 21 Feb 1989. 186p. Order Number DE90705960. Available from NTIS (US Sales Only), PC A09/MF A01 - OSTI.

This thesis deals with the generation of electric and magnetic fields in expanding plasmas. The theoretical model used to calculate the different field quantities in such plasma is discussed in part 1 and is in fact an analysis of Ohm's law. A general method is given that decomposes each of the forces terms in Ohm's law in a component that induces a charge separation in the plasma and in a component that can drive current. This decomposition is unambiguous and depends upon the boundary conditions for the electric potential. It is shown that in calculating the electromagnetic field quantities in a plasma that is located in the vicinity of a boundary that imposes constraints on the electric potential. Ohm's law should be analyzed instead of the so-called induction equation. Three applications of the model are presented. A description is given of the unipolar arc discharge where both plasma and sheath effects have been taken into account. Secondly, a description is presented of the plasma effects of a cathode spot. The third application of the model deals with the generation of magnetic fields in laser-produced plasmas. The second part of this thesis describes the experiments on a magnetized argon plasma expanding from a cascaded arc. With the use of spectroscopic techniques the electron density, ion temperature and the rotation velocity profiles of the ion gas have been determined. The magnetic field generated by the plasma has been measured with the use of the Zeeman effect. Depending on the channel diameter of the nozzle of the cascaded arc, self-generated magnetic fields with axial components of the order of 1% of the externally applied magnetic field have been observed. From the measured ion rotation it has been concluded that this magnetic field is mainly generated by azimuthal electron currents. 77 refs., 69 figs., 1 tab.

8837 (ITP–88-57) **Kinetic theory of low-frequency nonlinear structures in magnetized plasmas.** Sitenko, A.G.; Sosenko, P.P.;. AN Ukrainskoj SSR, Kiev (Ukrainian SSR). Inst. Teoreticheskoj Fiziki. 1988. 37p. Order Number DE90611306. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

Kinetic theory of self-consistent nonlinear oscillations in inhomogeneous magnetized plasmas is formulated. 41 refs.

8838 (ITP–88-58) **Renormalized microscopic theory of fluctuations in inhomogeneous magnetized plasmas.** Sitenko, A.G.; Sosenko, P.P.;. AN Ukrainskoj SSR, Kiev (Ukrainian SSR). Inst. Teoreticheskoj Fiziki. 1988. 44p. Order Number DE90611307. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

Nonlinear theory of fluctuations in inhomogeneous magnetized plasmas is formulated. 42 refs.

8839 (ITP–88-66) **Finite amplitude surface waves in cooled plasmas with smeared interface.** Kuklin, V.M.; Panchenko, I.P.; Chernousenko, V.M.;;. AN Ukrainskoj SSR, Kiev (Ukrainian SSR). Inst. Teoreticheskoj Fiziki. 1988. 8p. Order Number DE90611308. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS.

The nonlinear dynamics of surface wave propagation in cooled plasmas with smeared interface is discussed. The strong parametric instability with excitation of a short-wave spectrum of the Langmuir vibrations is shown to evolve in the inhomogeneous region near the plasma resonance. At the nonlinear stage of the process the short-wave spectrum exchanges energy with the surface wave. The small quasi-stationary perturbations of electrons density and plasma ions with broken quasi-neutrality condition arise in vicinity of the plasma resonance. 10 refs.

8840 (ITP–88-71) **Low-frequency oscillations in vlasov plasmas: the quadratic polarization approximation.** Sosenko, P.P.;. AN Ukrainskoj SSR, Kiev (Ukrainian SSR). Inst. Teoreticheskoj Fiziki. 1988. 20p. Order Number DE90611309. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

Nonlinear properties of low-frequency electromagnetic oscillations in inhomogeneous magnetized plasmas are studied. 15 refs.

8841 (IYaF–88-165) **Self-similar Langmuir collapse.** Malkin, V.M.; Khudik, V.N.;. AN SSSR, Novosibirsk (USSR). Inst. Yadernoj

Fiziki. 1988. 7p. Order Number DE90611310. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS.
MN-08689.

The first example of a three-dimensional self-similar solution of Zakharov equations for a supersonic Langmuir wave collapse is constructed. The parameters of this solution differ essentially from those predicted by the model of a highly oblate cavity, in particular, the maximum depth of the cavity exceeds the expected one by nearly four times. An explanation the expected one by nearly four times. An explanation of this discrepancy is given. 5 refs.; 1 fig.

8842 (IYaF–89-48) **Flute instability in mirror devices with intense atomic beam injection.** Masliev, I.E.; Ryutov, D.D.; Shajkhislamov, I.F.;;. AN SSSR, Novosibirsk (USSR). Inst. Yadernoj Fiziki. 1989. 29p. (In Russian). Order Number DE90611281. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.
MN-10127.

Radial injection of intense atomic beams, which are used for sustainment of material and energy balance in mirror devices, can have a strong influence on plasma stability with respect to flute perturbations. The effect is caused by the force acting on the flute from the atoms that are being trapped inside it. The paper contains formulation of general equations describing evolution of flute perturbations with account of this effect, and their analysis in some limiting cases. For localized flute perturbations, the atomic beams play a stabilizing role if the trapping efficiency decreases towards the plasma periphery. Stabilization of a mode m=1 in a plasma with sharp boundary is achieved at a sufficiently good beams focusing onto the axis. If the finite Larmor radius effects play a dominant role, the only allowed type of perturbation remains that of rigid displacement of a plasma filament. It is shown that the beams have no effect on the stability of such displacements. 9 refs.; 4 figs.

8843 (JAERI-M–89-103) **Numerical simulation of non-inductive current drive for tokamak plasmas with time-varying electron temperatures.** Neufeld, C.R. (Japan Atomic Energy Research Inst., Naka, Ibaraki (Japan). Naka Fusion Research Establishment); Yoshino, Ryuji; Yamamoto, Takumi; Uesugi, Yoshihiko; Kawashima, Hisato. Japan Atomic Energy Research Inst., Tokyo (Japan). Aug 1989. 14p. Order Number DE90733144. Available from NTIS (US Sales Only), PC A03/MF A01.

A relatively simple computer simulation program has been developed for the investigation of plasma behaviour during pulsed heating and current drive experiments. The temporal evolution of various plasma parameters, including the internal electric and poloidal magnetic field distributions, as well as the surface loop voltage, can be simulated under a variety of conditions. The results show clearly the difficulty of using the observed loop voltage behaviour alone as a measure of the RF-driven current, unless the plasma parameters have had sufficient time to approach equilibrium conditions during each distinct plasma phase. (author).

8844 (JAERI-M–89-104) **13-point Thomson scattering system for JFT-2M plasma.** Yamauchi, Toshihiko (Japan Atomic Energy Research Inst., Naka, Ibaraki (Japan). Naka Fusion Research Establishment); Neufeld, R.; Ogawa, Toshihide. Japan Atomic Energy Research Inst., Tokyo (Japan). Aug 1989. 17p. Order Number DE90733140. Available from NTIS (US Sales Only), PC A03/MF A01.

A 13-point Thomson scattering system mounted on the JFT-2M tokamak routinely provides reproducible electron temperature and density data. Good performance has been achieved with the help of a large collecting lens (capable of gathering data over a vertical 60-cm long plasma volume), the automatic transfer of data from a 180-channel attenuator into the CPU, the use of high-pass optical filters and a large polarizer plate to reduce stray light, and a better matching of LED calibration signal intensities to those of the scattered signals. Peaked density profiles are measured in improved L-mode (IL) plasmas, in contrast to those observed during the H-mode phase. IL-mode is caused by the broad and high electron temperature. With pellet injection, peaked density profiles are again observed. (author).

8845 (JAERI-M–89-106) **Results of the H-mode experiments with JT-60 outer and lower divertors.** Nakamura, Hiroo (Japan Atomic Energy Research Inst., Naka, Ibaraki (Japan). Naka Fusion Research Establishment); Tsuji, Shunji; Nagami, Masayuki and others. Japan Atomic Energy Research Inst., Tokyo (Japan). Aug 1989. 58p. Order Number DE90733146. Available from NTIS (US Sales Only), PC A04/MF A01.

In JT-60, hydrogen H-mode experiments with outer and lower divertors were performed. In the outer divertor, H-mode were obtained, similar to the ones observed in the other lower/upper divertors. Its threshold absorbed power and electron density were 16 MW and $1.8 \times 10^{19} m^{-3}$. In the two combined heatings with NB+ICRF and NB+LHRF, H-mode discharges are also obtained. Moreover, in new configuration of lower divertor, H-mode phases without and with ELM are obtained. Typical results of the lower divertor are shown to compare the H-mode characteristics between the two configurations. Improvement of the energy confinement time in the two divertors was limited to 10 %. Analyses on ballooning/interchange instabilities were carried out with precise equlibria of JT-60. These results showed that the both modes were enough stable. (author).

8846 (JET-R–89-04) **A model for the calculation of 2-D neutral transport in non-circular tokamak plasmas.** Core, W.G.F.;;. Commission of the European Communities, Abingdon (UK). JET Joint Undertaking. 1989. 19p. Order Number DE90611269. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

A fast, efficient procedure for the calculation of the 2-D distribution of neutral particles when the source of primary neutrals is due to point sources located on or near the plasma surface in non-circular tokamak containment systems is given. The transport of the neutral particles is described by integral equations for the particle density and flux to the wall of the vessel. The equations are reduced to a system of matrix equations which is then solved by numerical iteration. Comparison with more exact treatments of cases that are of particular interest are in good agreement. (author).

8847 (JET-R–89-10) **Maximum entropy tokamak configurations.** Minardi, E. (Commission of the European Communities, Abingdon (UK). JET Joint Undertaking); Lampis, G.;. Commission of the European Communities, Abingdon (UK). JET Joint Undertaking. 1989. 18p. Order Number DE90611183. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The new entropy concept for the collective magnetic equilibria is applied to the description of the states of a tokamak subject to ohmic and auxiliary heating. The condition for the existence of steady state plasma states with vanishing entropy production implies, on one hand, the resilience of specific current density profiles and, on the other, severe restrictions on the scaling of the confinement time with power and current. These restrictions are consistent with Goldston scaling and with the existence of a heat pinch. (author).

8848 (LA-UR–89-3742) **Doppler broadening measurements in FRX-C/LSM.** Baron, M.H. (Auburn Univ., AL (USA)); Chrien, R.E. Los Alamos National Lab., NM (USA). 1989. 5p. Sponsored by U.S. DOE Energy Research. DOE Contract W-7405-ENG-36. (CONF-8911130–6: 11. US/Japan workshop on field-reversed configurations and compact toroids, Los Alamos, NM (USA), 7-9 Nov 1989). Order Number DE90003397. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Measurements obtained in situ during field reversed configuration (FRC) formation show that the Doppler broadening ion temperature T_{cv} is larger by a factor of two or more than the ion temperature T_i derived from pressure balance and Thomson scattering. After a time comparable to an ion-ion equilibrium time, T_{cv} and T_i come into agreement with each other. An exception to this picture occurs in the lowest fill pressure condition (2 mtorr), for which $T_{cv} > T_i$ is maintained throughout the FRC lifetime. Earlier Doppler broadening measurements in FRX-B and FRX-C also showed persistent, anomalously high T_{cv} at low fill pressure. The initially high values of T_{cv} are probably caused by convective motion generated by the radial implosion. The low fill pressure results suggest an enhanced ohmic power input to the carbon ions. 7 refs., 3 figs.

8849 (LA-UR–89-3950) **Resistivity at the field null of the FRC plasma.** Gerwin, R.A. Los Alamos National Lab., NM (USA). [1989]. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract W-7405-ENG-36. (CONF-8911130–3: 11. US/Japan workshop on field-reversed configurations and compact toroids, Los Alamos,

NM (USA), 7-9 Nov 1989). Order Number DE90003656. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

In the absence of the major destructive instabilities, the configuration time is ultimately determined by particle and flux containment. If the profiles are "gentle," then the anomalous flux-loss rate depends essentially on the anomalous resistivity at the field null. Conventional electrostatic quasi-linear models of anomalous cross-field resistive diffusivity are based upon the use of $\vec{E} \times \vec{B}$ drift velocities, and hence break down at the magnetic field null. In this paper, an electromagnetic treatment valid at the field null is developed, based upon the presence of flute-parity perturbations. An expression for anomalous resistivity at the field null in the quasi-linear approximation is derived by averaging in the ignorable direction over the random phases of the perturbations. The expression is valid for arbitrary (non-local) radial shapes of the perturbing modes (for example, the eigenfunctions need not be centered at the field null), and for an arbitrary ratio of real frequency to growth rate. The effective resistivity due to flute perturbations of the MHD type will be considered. 1 ref.

8850 (PPPL–2663) **Canonical Hamiltonian guiding center variables.** White, R.B. Princeton Univ., NJ (USA). Plasma Physics Lab. Nov 1989. 11p. Sponsored by U.S. DOE Energy Research. DOE Contract AC02-76CH03073. Order Number DE90004372. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

A simplification of the canonical Hamiltonian variables for the guiding center motion of a charged particle in a general toroidal field is obtained using the Lagrangian formalism of Littlejohn. 11 refs.

8851 (RISO-M–2597) **Test of the feasibility and accuracy of mass and velocity measurements of pellets in flight in a microwave set-up with a pass-hole in the transmission line.** Andersen, V. (Risoe National Lab., Roskilde (Denmark). Physics Dept.); Andersen, P. Risoe National Lab., Roskilde (Denmark). Jun 1986. 46p. Contract JET-JD6/2160. Order Number DE90729636. Available from NTIS (US Sales Only), PC A03/MF A01.

The feasibility of mass and velocity measurements on pellets in flight without use of optical equipment has been tested. The mass is measured by a microwave system, and the velocity is measured by a time of flight in a double interaction with the microwave system. The influence of the size of the passholes in the microwave guide tube has been discussed. (orig.) With 29 figs.

8852 (RISO-M–2775) **On the plane steady flow of an ablating pellet under the impact of plasma electrons.** Tang, F.L. (Association Euratom-Risoe National Lab., Roskilde (Denmark). Physics Dept.); Chang, C.T. Risoe National Lab., Roskilde (Denmark). Mar 1989. 24p. Order Number DE90729637. Available from NTIS (US Sales Only), PC A03/MF A01.

To exclude the influence of expansion geometry on the pellet ablation rate, the ideal case of the ablation of a pellet in a constant area duct is considered. As a result of the lack of balance between the heating and the expansion process of the ablatant, a continuous flow is subsonic everywhere. The temperature of the ablatant has a limiting value. The mass ablation flux is determined by the downstream state of the ambient plasma electrons, and influenced by the state of the ablatant at the pellet surface. Compared with either the spherical or cylindrical ablated flow, the pellet ablation rate is more sensitive to the ambient plasma state, and is inversely proportional to the ablatant pressure at the pellet surface. (orig.) With 1 tab., 3 figs., 5 refs.

8853 (UCRL–95581) **Simulations of electromagnetic wave plasma interactions.** Kruer, W.L. Lawrence Livermore National Lab., CA (USA). 28 Aug 1986. 22p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. Order Number DE90002885. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The interaction of electromagnetic waves with plasmas is a topic rich in nonlinear effects with applications ranging from laser fusion to space plasmas. Computer simulations are a powerful tool to help understand the growing number of experiments in this area. Here we discuss some simulations of the Raman and two-plasmon-decay instabilities and of the nonlinear evolution of pondermotively driven ion acoustic waves. Some salient features are compared with experiments. 22 refs., 7 figs.

8854 **Serendipity is no accident, even in plasma research.** Birdsall, C.K. (EECS Dept., UC Berkeley, CA (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 2H.

After chasing and pushing electrons and ions for four decades, one becomes quite convinced of the role of serendipity in invention and discovery in plasmas. Dictionaries have several definitions, roughly the knack or aptitude for making or stumbling upon interesting or desirable discoveries in a casual manner or by accident. Shapiro says Serendipity is the art of finding something valuable when you are looking for something else. The author presents some experiences that tend to fit this definition. The list is chronologic, starting about 1948. The areas include: Nyquist diagrams for stability of velocity distributions 1948; orthogonal electron streams; plane-wave growth along one resistive-medium, resistive-wall amplifiers, rippled walls 1951; general admittance wall amplifiers 1953; Bessel bi-radial functions 1953; ring-bar vs. cross-wound helices for traveling-wave tubes 1953; virtual cathode oscillations; limiting currents; 6L6 effect explained 1959; thermionic converter and Q-machine instabilities; e-triggers 1960; rf ponderomotive force; plasma sheath modification; focussed electron beam 1959, 1964; forbidden region microwave filter 1964; and cloud-in-cell weighting, to reduce noise 1964, 1966.

8855 **Formation and decay of a high-beta plasma equilibrium driven by rotating magnetic fields.** Kuthi, A. (Dept. of Physics, Univ. of California, Los Angeles, CA (US)); Zwi, H.; Wong, A.Y. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4A7.

High-beta steady-state plasma equilibrium is generated using rotating magnetic fields in a way similar to the Rotamak experiment. Field-reversal has not yet been achieved because of insufficient RF power. The beta = 1 mirror configuration is stabilized with respect to gross magnetohydrodynamic modes by the ponderomotive force of the antenna near-field provided that the rotating field is strong enough to completely penetrate the plasma. The plasma is free-standing, well removed from the limiters and the RF antenna. In the absence of angular momentum input by the RF field the equilibrium decays, the plasma core expands radially. The radial speed of expansion is comparable to the ion sound speed indicating inertia limited motion.

8856 **Advanced heating techniques for formation of hot-electron plasmas in tokamaks and stellerators.** Quon, B.H. (AMPC, Inc. (US)); Dandl, R.A.; Fetzer, M.E.; Guest, G.E.; Miller, R.L. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 1P12.

A confocal, open resonator concept has been proposed for the formation and control of relativistic, hot-electron plasmas in tokamaks and stellerators. This confocal structure effectively localizes the upper-off-resonant, ordinary wave electric field in a narrow region for a large number of transits, thus forming an open high Q, resonant cavity suitable for heating hot electrons at their down-shifted, relativistic overtones. In addition to the focusing property, this structure can be designed to guide the injected waves in the toroidal direction, giving a toroidally uniform illumination pattern which is usually difficult to achieve by using a single wave-launcher. A conceptual design of such a confocal resonator for the Texas Experimental Tokamak (TEXT) has been carried out using an optical bouncing code together with the one-dimensional Fokker-Planck electron cyclotron heating model. The results of the authors studies confirmed that wave absorptions at the off-resonant frequencies are weak and multiple passes are generally required.

8857 Density and space potential fluctuation measurements in text using a heavy ion beam probe during an applied resonant magnetic field. Schoch, P.M. (Rensselaer Polytechnic Institute, Troy, NY (US)); Hickok, R.L.; DeGrassie, J.S.; Evans, T.E.; Jackson, G.L.; McCool, S.C.; Wootton, A.J.; Yang, X.Z. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 1P14.

The Heavy Ion Beam Probe (HIBP) on TEXT has been used to measure fluctuations in the electron density and space potential before and during externally applied resonant magnetic field. The HIBP has also measured the potential profile both before and during the applied field. The HIBP on TEXT consists of a 500keV accelerator presently operating with up to 100μa of Cs^+. This beam is passed through the plasma. Plasma produced Cs^{++} particles are detected using an electrostatic energy analyzer. The system can detect changes in n-tilde/n of the order of 0.2% and changes in the space potential which are greater than 3Vrms. Typically, density fluctuations are seen to decrease from edge values of greater than 10% to interior values of less than 1%. The applied resonant magnetic field forms both coherent magnetic islands and stochastic regions. Particle and electron energy transport is modified. The HIBP measurements show a flattening in the potential profile when the resonant field is applied. The plasma current has been varied, resulting in changes in the location of the resonant layer. The effects on the space potential for these changes is shown.

8858 Latest experimental results on the application of collisional magnetic pumping to heat a steady state plasma. Laroussi, M. (UTK Plasma Science Lab., Dept. of Electrical and Computer Engineering, Univ. of Tennessee, Knoxville, TN (US)); Roth, J.R. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 1P2.

In previous work the authors showed that collisional magnetic pumping can be an efficient way to heat a plasma if the right magnetic field perturbation is used. A sinewave perturbation proved to achieve second order heating. A sawtooth perturbation causes first order heating for small field modulation factors. This proved to have an energy increase rate two to three orders of magnitude larger than the previous case. An experimental attempt to observe heating is under progress. For this, two different apparatus have been designed, built, and tested. The first is a high-Q tunable parallel resonant circuit capable of generating a sinusoidal RF magnetic field. The second apparatus is a switching circuit capable of driving a current sawtooth through the exciter coil, which in turn generates a sawtooth magnetic field perturbation superimposed on the background magnetic field. The switch used is a TMOS (Metal-Oxide-Semiconductor) transistor. The experimental data along with the detailed design of the above apparatus is presented and discussed.

8859 Electron collision frequency enhancement and resistive drift wave turbulence. Spence, P. (Univ. of Tennessee, Knoxville, TN (US)); Stafford, S.; Roth, J.R. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 1P1.

Using capacitive probes and microwave scattering, a turbulent power spectrum was measured and related to the electron collision frequency determined by electron cyclotron resonance broadening. The turbulent power measured was assumed to be linearly proportional to the wave energy density W. Capacitive probes and a two channel microwave scattering system have now been calibrated in an attempt to quantitatively measure W. The results of these measurements and details of the measurement procedure are reported. The resistive drift instability is also reconsidered, with the addition of a turbulent collision frequency. The linear growth rate of these waves is proportional to the electron-ion collision frequency. Since resistive drift waves often behave as source functions in a turbulent plasma, they can affect the level of turbulence in the dissipative region of the spectrum which in turn changes the effective collision frequency.

8860 Anode sheath solutions using testing functions. Biblarz, O. (GTE Products Corp., Danvers, MA (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 1B5.

The anode sheath of a medium density discharge from plane electrodes is formulated. The plasma is assumed to be describable by the steady, one-dimensional species continuity and Poisson equations under constant properties. A single, highly non-linear equation for the electric field at the sheath is obtained. This equation is studied in terms of a testing function which is an educated guess for the electric field distribution. Testing functions meet the conditions of the problem only to a limited extent. Their importance lies in the fact that they afford quick, largely non-numerical solutions of some validity. The particular testing function proposed yields a set of electron and ion distributions which in turn determine the charge species generation at the sheath. The numbers are worked out for nitrogen and reasonable results are obtained with a monotonically decreasing profile as the E-field moves away from the anode. The resulting electron and ion profiles are also reasonable and the reactivity in the sheath is then found. It turns out that for sufficiently low currents and for two body recombination, the nitrogen results are realistic. It is anticipated that such testing function analysis will help establish criteria for conditions under which anode constriction takes place.

8861 Turbulent electric fields during strong beam-plasma interactions: Experiment and theory. . Benford, G. (Univ. of California Irvine, CA (US)); Dovrat, A.; Tzach, D.; Levron, D. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 1CH.

The authors used observations of satellites of forbidden helium lines to diagnose very strong electric fields. These fields of 10 kV/cm and higher, apparently derive from powerful instabilities generated by passing a 10 kA, 800 kV electron beam through a background helium plasma of density in the 10^{13}/cc range. They find that a probability distribution $\exp(-E^2)$ describes the fields, with at least 1% of the plasma volume experiencing $E^2>nT$. There is strong evidence that turbulent fields are not smoothly distributed through the beam-plasma volume. These results can be described by either a model invoking strong wave correlations over ranges exceeding a Debye length, or by a picture requiring that strong cavitons interact to form a statistical ensemble on times shorter than the average caviton decay time. Their experiments also yield spatial measures of $\langle E \rangle$ as a function of r and z in a cylindrical geometry, inside the beam and outside it, as a function of time. Further, they analytically model production of strong electric fields by beam-plasma instability, including modulational transfer in κ-space, plasma heating, radiation, and wave convection. They compare in detail the results of this numerically integrated model with direct observations of E(r,z,t), using beam voltage and current as input and requiring no fitting parameters.

8862 Refinement of the CR-39 range filter voltage diagnostic. Lapin, S.N. (The Univ. of New Mexico, Albuquerque, NM (US)); Davis, L.L.; Cooper, G.W.; Bailey, J.E.; Reyes, P.; Carlson, A.L. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 2P29.

CR-39, a solid-state nuclear detector, is being used to measure peak ion energies in the magnetically insulated transmission line (MITL) upstream of the diode of the Particle Beam Fusion Accelerator (PBFA-II) facility located at SNLA. This diagnostic uses the fact that ions passing through the CR-39 damage the plastic, leaving tracks that can be made visible by etching the plastic. A measure of

the ion energies that impact on the CR-39 can be obtained by placing filters of varying thicknesses over the CR-39. Only ions that have enough energy that their range exceeds the filter thickness will penetrate into the plastic and be recorded. From the stopping power of the filter material, one can determine the ion energy and thus the voltage across the MITL gap. Two issues concerning particle straggling should be addressed before the diagnostic can be considered definitive. One needs to be able to distinguish between ions that have sufficient energy to penetrate and be counted from those that straggle through. The other issue is the effect on straggling, if any, of using multiple layers of filters as opposed to a single filter of equivalent stopping power. Van de Graaff accelerator experiments were designed and performed to address these issues. To measure the straggling and saturation effects on CR-39, a filter grid was illuminated with protons of constant energy. Results are presented which show the effects of particle straggling for 8 and 15 MeV protons through Al and Ta filters. The effect on straggling through multiple vs. single filters is presented. These results are compared with predictions made by a Monte Carlo computer code. The ability to reduce detector saturation by placing CR-39 at various angles to the incoming ion flux is presented.

8863 Advanced measurement concepts for heavy ion beam probes. Heard, J. (Rensselaer Polytechnic Inst., Troy, NY (US)); Simcic, V.; Li, N.; Crowley, T.P.; Connor, K.A.; Khan, S.; Schoch, P.; Forster, J.; Hickok, R.L.; Jennings, W.C. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3P21.

The feasibility of measuring fluctuating magnetic fields in a tokamak using a heavy ion beam probe has been examined using the RENTOR tokamak and a 30 keV ion beam probe. A beam of particles passing through the plasma is deflected toroidally by the poloidal magnetic field generated by the plasma current. The toroidal velocity of the particle can then be related to the plasma flux function. The RENTOR experiment measures the displacement of the beam rather than its velocity change by recording the current collected by two toroidally displaced plates. Fluctuations in this signal can be compared with simultaneous B loop measurements. Rough estimates of the field variations are made and estimates of the beam probe's ability to detect magnetic fluctuations presented. The authors have also been investigating the algorithms used to process beam probe fluctuation data. An analysis technique that processes data in the time domain has been shown to produce better frequency resolution and smaller variances in the calculation of the phase between density and potential, and the phase between two density or two potential signals at different locations. Comparisons between this analysis technique and the standard frequency domain analysis techniques used by most plasma physicists are presented. Computer generated artificial data, and data from the heavy ion beam probe experiment on TEXT are used to illustrate the differences in the two techniques. The implications for the interpretation of the instabilities and transport estimates are discussed.

8864 Modeling of heavy ion beam probes for advanced fusion experiments. Simcic, V. (Rensselaer Polytechnic Institute, Troy, NY (US)); Resnick, J.; Crowley, T.P.; Connor, K.A. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3P20.

The authors calculated the particle trajectories and estimated the reaction rate between fast heavy ions and plasma electrons in a reversed field pinch magnetic configuration. The purpose has been to determine the parameters and beam requirements of a heavy ion beam probe experiment on such a device. Test cases using the MST and ZT-40 devices are presented. Unique features of a beam probe in a reversed field pinch experiment will be the toroidal deflection of the beam caused by the strong poloidal field, the lack of a strong known field such as the toroidal field in a tokamak, the access difficulties in a device with a conducting shell, the greater axisymmetry and smaller stray field outside the vacuum vessel and the relatively large density and temperature for typical magnetic field intensities. The operation of a heavy ion beam probe has also been considered for CIT. The primary purpose of this study is to define the developmental issues for the application of this diagnostic technique on reactors. One of the areas of concern is the detection and estimation of signal levels. Determination of reaction rates between the probing beam and the plasma particles has been hindered by the lack of experimental cross section data. Estimates of signal level have been made using the limited information now available. they are presented and their implications discussed.

8865 Electron density and collision frequency measurements in a pulsed, high power microwave discharge in low pressure air. Stalder, K.R. (Chemical Physics Lab., SRI International, Menlo Park, CA (US)); Eckstrom, D.J. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3P16.

The authors have measured electron densities and collision frequencies in low pressure microwave discharges using microwave interferometric techniques. Microwave discharges were formed at the constructive interference regions of an S-band microwave beam which was incident on an inclined metal plate. The discharge normally consisted of ionization layers parallel to the plate. With suitable choices of pressure, microwave power and pulse duration, it was possible to form single layer breakdowns. The range of pressures investigated was from 0.01 Torr to 3.0 Torr. They employed an X-band (9.60 GHz) Mach-Zehnder interferometer which probed normal to the plane of the discharge. Analysis of the data indicates that under single plasma layer formation conditions, the electron densities frequently reached overdense levels (for the S-band frequency), and that the collision frequencies (primarily dependent on interferometer scene power attenuation) were observed to be up to an order of magnitude higher than expected based on known momentum transfer cross section data. This presentation describes the interferometer technique. The results of the microwave and optical measurements are discussed.

8866 Fluid simulations of air breakdown experiments. Roussel-Dupre, R. (Los Alamos National Lab. (US)); Armstrong, W.T. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3P15.

A recent experimental campaign was conducted at the LLNL microwave facility to study the feasibility of producing artificial ionization patches in the atmosphere by means of crossed, high-power microwave beams. The time dependent 1-D fluid equations neglecting electron diffusion and ponderomotive effects are solved in conjunction with Maxwell's equation to obtain the time evolution of the breakdown plasma. The electromagnetic equations are cast in a form that includes the effects of focusing dielectric boundaries and reflecting surfaces. In addition, the coronal approximation with quenching is used together with a three-level atom to computer the expected light emission in the N_2^+ 3914 A 1st negative band and $N_2$3371 A 2nd positive band. The computed results are compared with high-time resolution (sub-nanosecond), photometric measurements of light emission in N_2 3371 and N_2^+ 3914 and interferometric measurements of electron density and collisionality.

8867 Propagation and breakdown in gases by short burst, high-power microwaves. Rappaport, H.L. (Univ. of Maryland, College Park, MD (US)); Latham, P.E.; Striffler, C.D. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3P12.

The authors are studying the propagation of pulsed high-power microwaves in the atmosphere. Their first calculations examine the individual processes in thier problem. These include reflection, absorption, transmission of normally incident electromagnetic radiation

onto a finite width resistive plasma and models of ionization of various gases by high-power RF. These results form the base for pulsed RF propagation calculations. They calculate the growth of a plasma in a one-dimensional gas cell using a low ionization rate, long-pulse model. Iterative numerical techniques permit simultaneous calculation of the electric field and plasma density profile as they evolve. They display results as a function of plasma density, plasma width and plasma neutral pressure. They study the validity of their model with the aid of a time domain analysis of the RF pulse response of a finite width resistive plasma. Time domain analysis is accomplished by Fast Fourier Transform methods. FFT results also illustrate transient effects associated with RF pulse propagation.

8868 **Production and diagnosis of a lithium anode plasma source.** Tisone, G.C. (Sandia National Labs. (US)); Dreike, P.L. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract AC04-76DP00789. (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 1D3.

The BOLVAPS/LIBORS scheme will produce a thin layer of lithium plasma on the anode of an ion diode. BOLVAPS (Boil Off Lithium Vapor Source) produces a thin layer of lithium gas by rapid evaporation from an ohmically heated thin film laminate, one layer of which is an LiAg alloy. LIBORS (Laser Ionization Based On Resonant Saturation) ionizes the gas using a dye laser tuned to the 670.8 nm $2s^2S$ to $2p^2P$ lithium resonant line. The scheme was demonstrated by pulse heating a thin tantalum foil coated with LiAg alloy and ionizing the Li vapor with a laser tuned to the 670.8-nm transition. In order to meet the objective of producing an anode plasma for the 800-cm^2 PBFA-II ion diode, development of techniques to fabricate thin (5 microns) metallic heater films on an insulating substrate has been necessary. In this paper the authors describe progress in the production and diagnosis of the lithium layer formed by pulse heating a molybdenum heater/LiAg laminate, sputter deposited on polished alumina. The neutral lithium vapor layer density as a function of distance from the substrate and time after the heating pulse will be measured by one- and two-photon fluorescence techniques using the single photon forbidden $2s^2S$ to $3d^2D$ transition. A plasma will be formed from the lithium vapor by LIBORS. The electron density of the plasma will be inferred from the linewidth of the Stark-broadened 460.3 nm $2p^2P$ to $4d^2D$ lithium line.

8869 **A relativistic fluid code for high-power microwave propagation.** Graham, G. (EG and G Energy Measurements, Los Alamos Operations, Los Alamos, NM (US)); Roussel-Dupre, R. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract AC08-88NV10617. (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3P13.

The propagation of a high-power microwave pulse through the atmosphere is treated with a relativistic fluid code. In this treatment, the first three moments of the Boltzmann equation are used to obtain fluid equations for electron density, mean momentum, and thermal energy. Particle, momentum, and energy exchange rates for elastic, inelastic, and ionization collisions are included in the calculation. The effects of electron spatial diffusion and the ponderomotive force are contained in the relativistic form of the Boltzmann equation. For an incident plane parallel microwave pulse, the fluid equations and Maxwell's equations are solved to obtain the temporal behavior of the fields as the microwave propagates through the atmosphere. Theory and applications of this relativistic fluid code are presented.

8870 **Power flow and microwave generation in magnetically insulated transmission line oscillators.** Peratt, A.L. (Los Alamos National Lab. (US)); Sheppard, M.G. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4P27.

Magnetrons and backward wave oscillators have long been used to produce microwave power with relatively high efficiency. The quest for high power microwave sources (>100 gigawatts) has pushed both pulsed-power and relativistic electron beam technologies into parameter regimes where high voltage breakdown, slow-wave structure of cavity closure by plasma, and the requirement for large external magnetic fields pose problems. The magnetically insulated transmission line oscillator (MILO) circumvents these by virtue of its low impedance and self-generated magnetic field. The authors study the frequencies of operation and power flow for the case of thin electron beams in parapotential flow past a slow wave structure via the linear analysis of Lemke and Clark. The dispersion characteristics, group velocities, and instability criteria are plotted for various slow wave geometries and dimensions. The extension of the analysis to the nonlinear operating regime is carried out. A detailed study of beam-corrugated anode interaction in coaxial geometry, instability growth and behavior, cavity field strengths and polarizations, and microwave spectrum is given. The authors report on the transition of the MILO mode of operation to smooth-bore magnetron mode of operation as the MILO current is increased to large values.

8871 **Observation of a high-frequency sheath-plasma instability.** Stenzel, R.L. (Univ. of California, Los Angeles, CA (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4C1-2.

A new instability has been identified which arises in sheaths surrounding electrodes in plasmas. It is observed that a positively biased electrode generates a high-frequency ($\omega \leq \omega_{pe}$) monochromatic oscillation at a frequency equal to the sheath-plasma resonance. The instability has a sharp threshold with dc bias, consists of a nonradiating fundamental mode and has many harmonics which are emitted as electromagnetic waves from the electrode. The instability is generated by particle transit time effects in the electron-rich sheath which behaves like a vacuum diode. For large transit time angles (ωtau $> \pi$) the real part of the sheath impedance can become negative which destabilizes the sheath-plasma resonance. The dependence of the imaginary part on dc bias causes frequency pulling. Detailed measurements of plasma parameters, instability spectra, field distributions, wavelengths, electric and magnetic polarizations for different electrodes have been performed in a highly controlled laboratory afterglow plasma (ne $\leq$ 10^{11} cm^{-3}, kTe $\leq$ 1 eV, $0 < B_o < 30$ G, dimensions 1 m x 2 m). These results are important to the field of antennas in plasmas, microwave generation in plasmas and the stability of plasma sheaths.

8872 **Effect of ECH induced electrostatic potentials on convective loss in the interchangeable module stellarator (IMS).** Storlie, C.A. (Torsatron-Stellarator Lab., Univ. of Wisconsin-Madison (US)); Talmadge, J.N.; Anderson, D.T.; Anderson, F.S.B.; Doerner, R.P.; Shohet, J.L.; Trost, P.K. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 1P11.

IMS is a modular stellarator with a major radius of 40 cm and a minor radius of 4 cm. Present operation uses 3 kW of electron cyclotron resonance heating to maintain a plasma for 10 msec. Particle confinement time in the machine is on the order of 1 msec. Density profiles in IMS are in general hollow with the density near the magnetic axis being less than the density near the edge of the plasma. The hollowness of the profile can be changed dramatically by moving the location of the electron cyclotron resonance layer. Because of the duration of the ECH, the plasma reaches a quasi-steady-state. By solving the time independent particle balance equation it can be shown that the hollow density profile can be attributed to a radial convection. The larger the magnitude of the convection, the more hollow the profile becomes. The convection appears to be driven ty ECH inducted electrostatic potentials in the plasma. Two dimensional measurements of the space potential using an emissive probe show that in the case where the destiny profile is fairly flat, the equipotential surfaces lie close to the magnetic surfaces. This results in poloidal and radial electric fields.

8873 Temporal evolution of hot spots and high temperature plasmas in a small gas-puff z-pinch. Deeney, C. (Physics International Co., San Leandro, CA (US)); Choi, P. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 2P52.

Previous time- and space-resolved X-ray diagnostics performed on a small (30 kV, 9 μF, 4 kJ) gas puff Z-pinch have indicated the presence of energetic electron beams and an associated high temperature plasma. It was shown that the electron beams occur in several bursts associated with different discharge conditions. High temperature plasmas and dense hot spots are observed in the presence of these beams. Here the authors present further measurements on the hard and soft X-rays. From these diagnostics, the electron temperature and the electron density of the hot plasmas and the hot spots are inferred and estimates are made of the current and energy of the intense electron beams.

8874 Observation of a pressure driven instability in the CTX spheromak. Wysocki, F.J. (Los Alamos National Lab. (US)); Fernandez, J.C.; Henins, I.; Jarboe, T.R. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3A2.

The spheromak, like most toroidal magnetic configurations, has a predicted beta limit. For these same configurations, it is often unclear what experimental significance predicted beta limits have, whether or not these limits can be reached and what plasma behavior is to be expected if these limits are reached. For instance, tokamaks often must struggle to reach their predicted beta limits, yet spheromaks often quote beta values above those predicted. Several recent changes in CTX spheromak operation have led to conditions where clear evidence of a pressure-driven instability is obtained. The observed instability leads to a distinct event in the discharge which are analyzed in detail. This event results in gross plasma motion, thus it is not necessary to rely on some proposed quasi-static reduction in cross field transport. The diagnostics crucial to this study include an eight cord CO_2 interferometer, multi-point Thomson scattering, ion temperature based in impurity doppler broadening, an array of 32 wall magnetic probes to determine both the magnetic equilibrium and any current-driven modal activity, three spectrometers which monitor oxygen and other impurity line emission, and four bolometers which monitor radiated power.

8875 Measurement of high frequency thermal fluctuations with antennas in plasmas. Ferreira, J.L. (Dept. of Physics, Univ. of California, Los Angeles, CA (US)); Stenzel, R.L. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4C3.

Fluctuation measurements in plasmas are of intrinsic interest, of use for plasma diagnostics, and of importance to low level signal propagation through plasmas. Although linear antennas are well understood in terms of coupling to electromagnetic waves their interaction with electrostatic waves and particles is less well known. The authors have observed high frequency ($f - f_{pe} - 1...8$ GHz) fluctuations in a pulsed dc discharge and Maxwellian afterglow plasma ($n_e < 10^{12}cm^{-3}$, $kT_e < 4$ eV, dimensions 1 m x 2 m) using various electric and magnetic antennas (balanced dipoles, loops, spheres). The antennas are connected via coaxial lines to a low noise (NF = 1.3 dB) tuned microwave receiver. For low impedance (50Ω) matching the received noise is due to the currents induced in the antenna associated with individual electrons passing by the antenna. The fluctuation spectrum extends from below to above $\omega = \omega_{pe}$ with no enhancement at $\omega = \omega_{pe}$. In the evanescent regime ($\omega < \omega_{pe}$) the observed noise is not due to waves (black body, bremsstrahlung, Cerenkov) but moving charges. However, for high impedance matching of a balanced dipole the received nose exhibits only a single sharp maximum at the electron plasma frequency which represents a measurement of fluctuating electric fields enhanced by the plasma permittivity ($K = 1 - \omega_p^2/\omega^2$). The sheath-plasma resonance of a dc biased antenna can also produce enhancements in the observed noise spectrum. Thus, a correct interpretation of observed fluctuation spectra requires a knowledge of the coupling of antennas to electrostatic fields/waves.

8876 Time and space resolved measurements of x-ray emission from a plasma implosion. Porter, J.L. (Sandia National Labs. (US)); Hammel, B.A.; McGurn, J.S.; Ruggles, L.E. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract AC04-76DP00789. (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 2P51.

The authors use two complimentary diagnostics to make time- and space-resolved measurements of the x-ray emission above $\approx$1keV from argon and neon gas puff Z-pinch implosions on the Proto-II accelerator. One diagnostic is streaked in time and provides a continuous time history of the x-ray emission, with one dimension of spatial resolution. The other diagnostic is framed, and provides two-dimensional snapshots of the implosion. Through a comparison of the data from these two diagnostics, they show the time evolution of the radial x-ray emission profile as the gas puff implodes and stagnates on the target. The data is compared with a simple model of Z-pinch implosions.

8877 Surface potential of a relativistic electron beam accelerator in the ionosphere. Nguyen, K.T. (Naval Surface Warfare Center, Silver Spring, MD (US)); Uhm, H.S. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P9.

In this work, the authors consider an initially uncharged spherical conductor (accelerator) of radius a, injecting a highly relativistic electron beam of constant current (-I) into the open space in a direction normal to its surface. In the absence of any neutralizing medium, the potential due to the positive charge left behind can build up to such a point that injection is no longer possible. This problem is alleviated in the presence of the ionospheric plasma due to the neutralization current that resulted from the plasma electrons. Assuming ions do not move, the neutralization can be seen as an orderly process, in which shells of background electrons at different radii successively collapse into the conducting sphere. The equation of motion of a shell (or an electron) at an initial radius r_0 is presented.

8878 Hydrodynamic experiments for PBFA II. Perry, F.C. (Sandia National Lab., Albuquerque, NM (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract AC04-76DP00789. (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6B6-7.

Hydrodynamic stability is an important issue for ICF targets. In this paper the authors discuss their approach to the stability problems. Within this context, they describe some of the theory and diagnostics that are being developed for PBFA II target experiments. The theoretical approach is a simple molecular dynamics model, which explores the seeding of hydrodynamic instabilities through spatial heterogeneities in material properties. Temperature change seeds instabilities through the solid/liquid phase transition. From the model, one computes the rate of growth of a fluid-like state at heterogeneous locations within the target shell. One can then compare this rate with an appropriate hydrodynamic velocity in order to assess the extent of homogenization of material properties. In addition their description of the theoretical and diagnostic approach to hydrodynamic experiments, they also report on some recent laser ablation data a wavelength of 0.7 μm which, along with previous light-ion ablation data, appear to support the theoretical concepts.

8879 Plasma opening switch studies of the applied Bz diode on the LION accelerator. Struckman, C.K. (Lab. of Plasma Studies, Cornell Univ., Ithaca, NY (US)); Kusse, B.R.; Meyerhofer, D.D.; Rondeau, G. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P24.

The LION accelerator, 1.5 MV, 4Ω, at Cornell University is being used to study the characteristics of an applied B_z, or, barrel diode. A plasma opening switch (POS) has been used to shape the voltage pulse seen by the diode. The results of a series of experiments utilizing a POS are presented. The plasma switch geometry is unique, with the plasma source located inside the center conductor of a coaxial transmission line. The switch region is located between the 17 cm radius anode and the 23 cm radius cathode. The switch is constructed of a flashboard plasma source bent into an azimuthally symmetric ring. The axial length of the plasma is only about 2 cm; which is much smaller than the switch radius. The plasma diffuses into the anode-cathode space through axially oriented slots in the anode. The plasma in the switch region has been characterized during static testing (no generator pulse) using Faraday cups. By using time of flight calculations, the Faraday cups give rough estimates of both the plasma density and velocity. Since the generator pulse is so short (100 ns) these static characterizations are indicative of the plasma when the voltage pulse is present. This low density, fast plasma produced the best results for the diode voltage pulse. Results from recently constructed Langmuir probes are also presented.

8880 Design of a 10 MW, 35 GHz phase-locked gyrotron oscillator driven by a pulseline accelerator. Gold, S.H. (Naval Research Lab. (US)); Fliflet, A.W. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4P38.

An experiment has been designed to address the issues involved in phase-locking a high peak power gyrotron device driven by a pulseline accelerator. The 10-MW, 35-GHz experimental design is based on a multi-cavity approach, using a solid 1-MeV, 100-Amp, 55-nsec electron beam. The critical elements of the device are the electron beam and the microwave circuit. The electron beam must have a low parallel velocity spread combined with a pitch ratio α of approximately 0.75. To meet these requirements, a helix-gun approach will be used, in which a cold 100 A electron beam with a low initial value of transverse momentum is produced by beam aperturing in a plasma-induced field-emission diode immersed in a strong axial magnetic field. The required beam α is induced by means of a helical wiggler magnetic field followed by adiabatic compression of the beam by the axial magnetic field in the vicinity of the diode, a helix period of 4 cm was selected. The magnetic field compression will be approximately four to one.

8881 Anomalous diffusion of a transverse magnetic field into a high beta neutralized ion beam. Song, J. (Dept. of Physics, Univ. of California, Irvine, CA (US)); Wessel, F.J.; Fisher, A.; Rostoker, N. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4P52.

UCI experiments on the propagation of a neutralized ion beam into a transverse magnetic field, B_y, confirm that the beam propagation is governed by the $E_x \times B_y$ drift for low- and high-beta cases, where beta (β) is the ratio of beam kinetic energy to magnetic field energy and $\rightarrow E_x$ is due to the self-induced polarization of the beam, resulting from the opposite deflection of the ions and electrons across the transverse magnetic field. In these earlier experiments, the authors observed that the magnetic field diffuses into the neutralized ion beam on a timescale much shorter than the beam risetime (i.e., tens of ns vs 100 ns) even for the high beta case, $\beta < 400$. In all cases the measured diamagnetism does not exceed 15%. Their recent experiments are performed at higher ion beam energy and higher current density (~400 kV, 14 kA, 20 A/cm^2, 0.5 μs) injected into a transverse magnetic field B_y = 0-400 G. They observe similar rapid diffusion of the magnetic field in addition to rapid oscillation of the polarization electric field E_x. Measurements of the oscillation frequency inside the polarization sheaths indicate higher frequency oscillation in the electron sheath (~tens of MHz) than in the ion sheath.

8882 Microwave interferometry of PEOS plasma sources. Weber, B.V. (Naval Research Lab., Washington, DC (US)); Commisso, R.J.; Goodrich, P.J.; Hinshelwood, D.D.; Neri, J.M. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P20.

A 70 GHz microwave interferometer is used to measure the electron density for various configurations of sources used in plasma erosion opening switch (PEOS) experiments. The interferometer is a phase quadrature system, so the density can be measured as a function of time without ambiguity. Measurements have been made for carbon guns and flashboards driven by a .6 μF. 25 kV capacitor. The plasma density from a gun rises to its peak value in about 10 μs. Then decays in the next 40 μs. A metal screen placed between the gun and the microwave beam attenuates the plasma density by a factor greater than the geometrical transparency of the screen. Density measurements as a function of distance from the gun are analyzed to give the plasma spatial dependence, and the particle flux density and flow velocity are calculated from the continuity equation. Density values used to model previous PEOS experiments are comparable to the values measured here. The flashboard sources produce a denser, faster plasma that is more difficult to diagnose with the interferometer than the gun plasma because of refractive bending of the microwave beam. Reducing the plasma length reduces the refractive bending enough that some measurements are possible. Direct comparison with Gamble II PEOS experiments that used these flashboard sources may not be possible at this frequency because of refraction, but estimates based on measurements at larger distances give reasonable agreement with values used to model these experiments. Other measurements that will be presented include the effects of plasma flow against metal walls, effects of changing the driving current waveform, measurements made in actual experimental configurations and comparisons with Faraday cup and electric probe measurements.

8883 2.5D EM direct implicit PIC simulation. Hewett, D.W. (Lawrence Livermore National Lab., Livermore, CA (US)); Langdon, B.A. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract W-7405-ENG-48. (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6P47.

The physical parameter regime accessible to the PIC method has been expanded by the recent development of implicit PIC algorithms. The Direct Implicit PIC algorithm provides the basis for the recently constructed 2.5D EM code AVANTI that now routinely runs a variety of problems exploiting the increased flexibility in time step selection. The authors find the code runs stably with large Δt and is robust with respect to large fluctuations occurring due to small numbers of particles per cell N_c. The implicit susceptibility chi is computed so that a nonlinear instability associated with small N_c is avoided without explicit smoothing. The components of the implicit Maxwell's equations are strongly coupled, necessitating simultaneous solution of equations for the advanced E. They solve the set of equations by simultaneous splitting in 2D. In addition, extension and generalization of the explicit PIC divergence correction step, necessary to maintain Gauss' law, is needed. By using a more complex form that incorporates some implicit shielding, the correction step prevents spuriously large implicit currents from moving across strong magnetic fields and across steep density gradients from vacuum regions. An overview of the algorithm is presented along with a

recent theoretical extension to relativistic plasma representation. Selected applications that demonstrate the capabilities and advantages of the direct implicit PIC method are presented.

8884 Experimental study of cusptron amplifiers. Namkung, W. (Naval Surface Warfare Center, Silver Spring, MD (US)); Choe, J.; Boulais, K.; Ayres, V.; Uhm, H. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4P42.

A compact and high-power microwave amplifier under development is based on the cusptron concept which utilizes the negative-mass instability of axis-rotating electron beams. Through a series of recent experiments using a low-energy, axis-rotating beam of 28-30 kV and 0.8-3.5 A, the NSWC cusptron oscillator has produced microwave radiation at fundamental and harmonic cyclotron frequencies in either a circular or a multivane circuit. With a six-vane circuit, microwave radiation at 6.0 GHz (sixth harmonic of the electron cyclotron frequency) is generated at more than 10 kW peak power and 10% efficiency. In the amplifier mode of operation, both input and output RF couplers in the six-vane circuit are used for injection and extraction of microwaves. The electron beam and circuit parameters are the same as the previous oscillator experiment. In this paper, the authors present preliminary experimental results of the NSWC cusptron amplifier operated at a low power level.

8885 The plasma wake field accelerator with axial magnetic field. Ting, A. (Berkeley Research Associates, Springfield, VA (US)); Esarey, E.; Sprangle, P. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6P55.

Plasma waves can be utilized to accelerate electrons to very high energies. Excitation of plasma waves with large electric fields could be accomplished by the wake field produced by a driving beam in the plasma wake field accelerator (PWFA). The PWFA has been analyzed in one- and two-dimensions in the absence of an externally applied axial magnetic field. An applied magnetic field may be necessary in order to: confine and guide the driving electron beam through the plasma, reduce the various transverse beam plasma instabilities, and to confine the plasma. The effects of an axial magnetic field on the PWFA are studied.

8886 Spectroscopic investigation of plasma parameters in plasma focus experiments. Begay, F. (Univ. of Maryland, College Park, MD (US)); Fine, T.A.; Griem, H.R.; Hess, R.A.; Moreno, J.; Rhee, M.J.; Schneider, R.F. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6P42.

The method of time-resolved atomic emission spectroscopy is employed to measure plasma parameters such as electron density, electron and ion temperature, fluctuating electric field and potential in plasma focus experiments. The Mather type coaxial plasma focus apparatus (6 κJ, 14 κV) is used to product plasma focus discharge in helium and neon gases (1–10 Torr). The plasma radiation emission from the focus region is analyzed with a 1-m diffraction grating spectrograph which is coupled to a gated optical multichannel analyzer. Preliminary experimental results on the correlation between the plasma parameters and the ion energy and current are presented.

8887 Experimental high power plasma-filled backward wave oscillator results. Minami, K. (Univ. of Maryland, College Park, MD (US)); Lou, W.R.; Destler, W.W.; Kehs, R.A.; Granatstein, V.L.; Carmel, Y. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4P34.

Previous results have indicated that a background gas can be used to increase the output microwave power of relativistic backward wave oscillators (BWOs) two or three times the vacuum case. In their experiments, two methods of plasma production are investigated in detail: the use of the electron beam to ionize a background gas, and the use of a plasma gun to inject a background plasma into the slow-wave structure of a BWO. It is found in the first case that there was a resonant increase in microwave power at a particular pressure of the background gas by a factor of ten. In the second case, power also increased compared with power production in vacuum. Detailed results are presented and the relative merits of the two approaches is discussed and compared with theoretical expectations.

8888 Ionization balance studies in annular x-ray laser targets. Hammel, B.A. (Sandia National Labs. (US)); Hussey, T.W.; Spielman, R.B.; Matzen, M.K. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract AC04-76DP00789. (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5A10.

In experiments performed during the past two years on Proto II (a 10-TW pulsed-power accelerator), the authors' have imploded annular plasmas in order to create a radiation pump source for x-ray laser physics studies. Their x-ray laser concept is a cylindrically symmetric configuration in which the puised-power-driven Z-pinch stagnates on a thin-walled annular target. According to calculations, x-rays produced by the stagnation of the imploding plasma on the target should first create the laser medium by thermally exploding a thin layer from the inside of the annulus and then photoionize the lasant material to the F-like state. Lasing is expected to occur in the Ne-like ion as the plasma recombines. A series of experiments, performed without the Al converter layer (required for photoionization of the Ne-like ion), has shown n=3-2 transitions of increased brightness, indicating a production mechanism other than photoionization. Possible explanations for the discrepancy between calculations and experiment are a mix of the lasant with surrounding CH and the effect of significant implosion nonuniformities on the stagnation. The authors present data from these experiments and propose that this data is consistent with some models that describe the response of the annular target to the imploding gas puff.

8889 High-power microwave generation from a frequency-stabilized virtual cathode source. Fazio, M.V. (Los Alamos National Lab., H827, Los Alamos, NM (US)); Hoeberling, R.F.; Kinross-Wright, J. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5B5.

The evolution of virtual cathode based high-power microwave-source technology has been directed primarily toward achieving higher peak-power levels. As peak powers in excess of 10 GW have been reported, attention has begun to focus on techniques for producing a more frequency- and phase-stable virtual cathode source. Free-running virtual cathode microwave sources characteristically exhibit bandwidths in a single pulse of tens of percent, which makes them unsuitable for many applications such as power sources for phased array antennas and microwave linear accelerators. Presented here are results of an experimental approach utilizing a high-Q, resonant cavity surrounding the oscillating virtual cathode to achieve frequency stabilization and repeatable narrow-band operation. A cylindrical cavity resonator is used with the microwave power being extracted radially through circumferential slot apertures into L-band waveguide.

8890 Stability of an intense beam system with no applied magnetic field. Zhang, X. (Univ. of Maryland, College Park (US)); Striffler, C.D.; Yao, R. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P7.

An intense electron beam is injected into a long drift tube with no applied magnetic field. In order for the electron beam to propagate, ions are supplied by electron beam ionization and ion-ion avalanche ionization of a neutral gas cloud that is located immediately downstream of the electron injection surface. The properties of this localized source region are the rate Si (C/sec) at which the ions are formed and the potential Vio at which the ions are created. The ions and beam electrons are then able to propagate downstream with the ions initially at rest gaining kinetic energy as they fall through the potential difference Vio - V, and the beam electrons losing kinetic energy due to the downstream potential depression V. Self-consistent Vlasov equilibria have been found for the downstream electron-ion beam propagating system. A temperature T_* exists where the equilibria is charge neutral and has no current neutralization provided by the ions (zero ion velocity) when the ion temperature is zero. Acceptable equilibria exist for the system for temperatures $Te \leq T_*$. The authors find that temperatures just below T_* possess system parameters that are very close to the calculated values for ion-ion avalanche ionization in the localized gas cloud. Possible instabilities are examined. The linear dispersion relation derived is analyzed for some cases.

8891 Plasma channels for electron beam transport. Schneider, R.F. (Naval Surface Warfare Center, White Oak, Silver Spring, MD (US)); Smith, J.R.; Moffatt, M.E.; Nguyen, K.T.; Uhm, H.S. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P6.

In recent years, there has been much interest in transport of intense relativistic electron beams using plasma channels. These channels are formed by either: ionization of an organic gas by UV photoionization or electron impact ionization of a low pressure gas utilizing a low energy (typically several hundred volts) electron gun. The second method is discussed here. As their electron gun, the authors used a 12 volt lightbulb filament which is biased to -400 volts with respect to the grounded 15 cm diameter drift tube. The electrons emitted from the filament are confined by an axial magnetic field of –100 Gauss to create a plasma channel which is less than 1 cm in radius. The channel density has been determined with Langmuir probes and the resulting line densities were found to be 10^{11} to 10^{12} per cm. When a multi-kiloamp electron beam is injected onto this channel, the beam space charge will eject the plasma electrons leaving the ions behind to charge neutralize the electron beam, hence allowing the beam to propagate. In this work, the authors performed experimental studies on the dynamics of the plasma channel. These include Langmuir probe measurements of a steady state (DC) channel, as well as time-resolved Langmuir probe studies of pulsed channels. In addition they performed experimental studies of beam propagation in these plasma channels. Specifically, they observed the behavior of current transport in these channels. Detailed results of beam transport and channel studies are presented.

8892 Envelope solitons in nonuniform media. Kuehl, H.H. (Univ. of Southern California, Los Angeles, CA (US)); Zhang, C.Y. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6P31.

The soliton solutions of the nonlinear partial differential equation $iq_t + \alpha(t)q_{chichi}$ + absolute value of $q\ ^2q - i\beta(t)q_{chichichi} = 0$ are considered. This equation governs a wide variety of nonlinear waves in nonuniform plasmas, e.f., ion acoustic waves or Trivelpiece-Gould modes,as well as waves on an axially-nonuniform optical fiber. In many applications, the variable t is actually distance, whereas chi is time. The terms involving α and β are due to dispersion and higher-order dispersion, respectively. When $\beta = 0$ and α is constant, the equation becomes the nonlinear Schrodinger equation for which soliton solutions are well known. Two special cases are considered. The first is that in which the higher order dispersive term is negligible, $\beta = 0$. Grimshaw has given an exact soliton solution in the special case in which $\alpha - \exp(t/t_o)$, and has found the lowest-order perturbative solution based on the assumption that $\alpha(t)$ varies slowly. The authors carry out the perturbative solution to higher order to find how the nonuniformity of the medium modifies certain important soliton properties such as shape, amplitude, width, and phase shift. The second case is that in which α = const and the higher-order dispersive term β is a small perturbation. They carry out a perturbative expansion to determine the modification of the soliton shape, speed, and phase shift as well as the nonlinear frequency shift and radiation due to the higher-order dispersive term.

8893 Thomson spectrometer studies of collectively accelerated ions. Rhee, M.J. (Univ. of Maryland, College Park, MD (US)); Begay, F.; Fine, T.A. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6B3.

Results from numerous collective ion acceleration experiments with linear electron beams show that the ions have a complicated structure: peak energy many times that of electron beam energy, wide energy spread, multiple charge states, etc. The method of time-integrated and time-resolved Thomson spectroscopy is employed to characterize the ion emission from the collective ion acceleration process. The Thomson spectroscopy provides multiple information such as energy, momentum, velocity, and charge state simultaneously. Typically, a 0.5 – 1 MeV, 70 – 140 kA, 100 ns, 2.54 cm diam e-beam is injected through a foil anode into a 6 in. diam downstream drift tube. The source of ions is localized neutral gas cloud puffed near the anode foil prior to injection of the e-beam. The gases used are hydrogen, helium and their mixture. The ions accelerated in the axial direction are measured by a Thomson spectrometer system. The time-integrated energy spectra for H^+, He^+, and He^{++} ions will be constructed from the spectrogram. In addition, time-resolved spectrometer measurement of H^+ ions are also underway using the same spectrometer operating in a time-resolved mode. The authors present details of time-integrated measurements and preliminary results of time-resolved measurements.

8894 Multichord axial interferometry on the coaxial slow source. Smith, R.J. (Univ. of Washington, Seattle, WA (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P18.

The authors describe a 6-chord, 632 nm HeNe full quadrature interferometer constructed to measure density profiles on the Coaxial Slow Source at the University of Washington. The system employs a speaker-driven end mirror to fix the background phase within the time in which data is collected. The interferometer uses the Michelsen configuration and 2 channels of data are acquired for each chord. Silicon PIN photodiodes are used to measure the interference pattern. It is found that the phase angle between channels fluctuates and is not always close to the ideal value of 90^0. Success in deciphering the information using both channels is discussed. Details concerning background mechanical noise, accuracy of data, and system stability are presented. The interferometer has been successfully used to acquire data from the Coaxial Slow Source, which generates field-reversed configurations on time scales of 50 μs and longer. End-on viewing of the plasma was employed at 6 radial positions in the annular region between the coils to provide radial profiles of integrated density with fill pressures ranging from 2 to 100 mTorr. This data is presented, along with its interpretation as aided by 2-D simulations of the machine operation.

8895 Radial transport modification in Phaedrus-B tandem mirror using floating end rings. Breun, R.A. (Univ. of Wisconsin-Madison (US)); Brouchous, D.A.; Hershkowitz, N.; Majeski, R.; Persing, H.; Wen, Y.J. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P10.

Experiments with grounded end rings and floating end rings have been carried out in the Phaedrus-B tandem mirror. It is demonstrated that floating the end rings modifies the central cell density. This modification in density is believed to be the result of changes in axial and radial transport. Radial potential profile measurements are made in the central cell using self-emissive probes. These measurements indicate that the floating end rings reduce the overall central-cell plasma potential. In addition, the relative plasma potential (compared to the on-axis value) is shown to decrease at large radii when the end rings are floated. The central-cell radial density profile, potential profile and the total endloss current (electron, ion, and net) with floating and grounded end rings are compared.

8896 Radial profiles of electron temperature and density on the ZT-40M reversed field pinch. Pickrell, M.M. (Los Alamos National Lab., Los Alamos, NM (US)); Sandoval, J.S. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P15.

A radially resolved Thomson scattering diagnostic has just become operational on ZT-40M. The scattered signal is measured in 10 separate wavelength channels, at ten spatial locations across the plasma cross section. The system consists of a 7 joule, 300 micro-radian laser, and is focussed to a 2 mm waist diameter. The collection system uses double gaussian lenses which focus the laser image onto 10 fiber optic bundles. The fiber bundles are directly connected to a novel spectrometer. The spectrometer operates at f/2 to capture most of the light from the fibers, and achieves excellent ruby rejection by using several reflecting filters. It also images the dispersed light directly onto a photomultiplier tube with 100 anodes, arranged in a 10 by 10 array. Details of the system design are presented. Preliminary profiles of electron temperature and density have been measured on ZT-40M for plasma currents: 120 kA $\leq I_{rho} \leq$ 180 kA and densities: n_e – 1-4x10^{19} m^{-3} at early times in the discharge. The density profile is typically quite flat to within 2 cm of the plasma edge. The temperature profile is broad but is characterized by an unusual feature in the outer region.

8897 Spectral diagnostics in the utsi railgun plasma armature. Sedghinasab, A. (Center for Laser Applications, Univ. of Tennessee Space Institute, Tullahoma, TN (US)); Keefer, D.; Crowder, H. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5C11.

Time integrated, high resolution spectroscopic measurements of the in-bore arc radiation in the UTSI 1-cm railgun has produced an absorption spectra from which information associated with the relative concentration of various elements in the plasma, the electron density, and possibly the temperature can be obtained. The observed spectrum (290-350 nm) contains two absorbed, well-resolved copper resonance lines (324.7 and 327.4 nm) as well as an unresolved profile of two absorbed aluminum resonance lines (308.2 and 309.3 nm). The relative absorptance of the two elements results in a number density ratio (Cu/Al) of about 40 +– 10% in the observed region. Electron density is approximated from the line widths to be 4 x 10^{18} cm^{-3} in the observed layer. The continuum radiation has an apparent positive slope with wavelength which is consistent with radiative transfer calculations for an aluminum plasma within this wavelength range.

8898 Muzzle voltage and contact potential in plasma armature railguns. Keefer, D. (Center for Laser Applications, Univ. of Tennessee Space Institute, Tullahoma, TN (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5C12.

The voltages measured at the muzzle of a railgun have values greater than those calculated from the one-dimensional models for railgun plasma armatures. This excess voltage is attributed to the contact potential and has a value of several tens of volts. The use of experimentally measured muzzle voltage to determine plasma properties has required that this contact potential be subtracted in order to obtain meaningful results. A two-dimensional model of the plasma armature has been analyzed which shows that a portion of this excess voltage arises as a result of the reduced conductivity in the thermal boundary layer of the rail. Another portion arises from the speed voltage and is confined to a region near the rails within the velocity boundary layer thickness. The voltage drop in the boundary layer is not constant along the length of the armature, and the implications of this effect of the boundary conditions for one- and two-dimensional models of the railgun plasma armature are discussed.

8899 Computer simulation of electron beam injection from the space shuttle. Lin, C.S. (Southwest Research Institute (US)); Koga, J. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P4.

Two-dimensional numerical simulations using an electro-static particle-in-cell code are conducted to study injection and propagation of a nonrelativistic electron beam from the Space Shuttle. The beam width is assumed to be much less than the spacecraft dimension. When the spacecraft is charged positively, the ambient electrons and ions impinging upon the spacecraft are considered lost via recombination. However, when the spacecraft potential is neutralized, return electrons are reflected from the surface. The spacecraft charging potential is proportional to the beam current. A portion of the electron beam is found to propagate away when the beam density is comparable to the ambient density. The effects of beam interactions with the neutral gas on the spacecraft charging potential are also examined. The simulation results are discussed with respect to the experimental data from the Space Experiment with Particle Accelerator (SEPAC) of the Spacelab 1 mission.

8900 Electron beam stability in compact recirculating accelerators. Hughes, T.P. (Mission Research Corp., Albuquerque, NM (US)); Godfrey, B.B. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P5.

Stable beam transport is a central issue in developing high-current electron beam recirculating induction accelerators. Potentially dangerous instabilities include the electromagnetic three-wave, negative-mass, and beam break-up. The three wave instability is similar in nature to the free-electron laser instability, but at longer wavelength. It occurs in accelerators which use quadrupole strong focusing (Stellatron, Torsatron, Spiral Line Induction Accelerator). The instability, which produces transverse kinking of the beam, is particularly fast in the absence of a longitudinal magnetic field. The authors present estimates of growth for proposed accelerator designs. The fastest-growing negative-mass modes are short-wavelength modes which, due to toroidal effects, can resonate with electromagnetic cavity modes. They find that this instability can create a large energy spread on the beam during the acceleration time. Unless strong-focusing is applied, this eventually leads to current loss.

8901 Plasma simulations on an unstructured grid. Fritts, M.J. (Science Applications International Corp., McLean, VA (US)); Drobot, A. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5D4.

The accuracy of plasma simulations in complicated geometries often depends on the ability to properly resolve and describe boundary structures. The authors describe in this paper an approach for boundary conformal plasma simulations using triangular meshes in three dimensions. They constructed a code (BERMUDA) with arbitrary connectivity. The restriction imposed on the grid structure is that all of the triangles on the mesh have angles less than 90^0. Under this restriction the triangular grid and the conjugate mesh have

a simple relationship which permits the construction of simple and accurate algorithms. With BERMUDA they have implemented a number of solvers which include electrostatics, electromagnetics, hydrodynamics, and particle-in-cell simulations. The properties of the mesh structure and of algorithms for the various solvers are described. Results of simple calculations are presented.

8902 **Current accretion in a ion and cluster emitting pinch with fusion reactions.** Bortolotti, A. (Stevens Institute of Technology, Hoboken, NJ); Brzosko, J.S.; Mezzetti, F.; Nardi, V.; Powell, C.; Zeng, D. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6P44.

Non random fluctuations in the emission of MeV ions and clusters have been observed in self-field dominated pinches with a non uniform structure on a μ space scale and a high neutron yield/shot, Y_n, from D-D fusion reactions. The particle emission increases with Y_n in all directions up to $Y_n \leq Y_n$, where Y-bar is the mean value of y_n from hundreds of shots under identical conditions. The particle emission decreases uniformly for $Y_n >$ Y-bar$_n$ and becomes vanishingly small (except for the charged products of fusion reactions) when Y_n approaches the peak yield ≥ 2 . Y-bar$_n$. This is consistent with an enhanced confinement of accelerated D^+ ions (during and after the pinch disintegration) within a region of dia. 1-2 cm. The emission of particles is not impaired by the pinch-generated magnetic field if clusters with a charge/mass ratio $Z/M \simeq 0$ form the bulk of the ejected particle population which may disintegrate on flight. The continuous accretion of current layers (which are trailing the leading current sheath) in the pinch region was stimulated in experiment by inserting suitable field distortion elements in the interelectrode gap. The current distribution in the interelectrode gap was monitored. Current accretion in the pinch region is possible. The bearing of the fusion reaction yield of heavy ions in the pinch on the mechanisms of confinement and of beam-plasma target enhancement is clarified.

8903 **Initial operation of a Cherenkov cyclotron autoresonance maser.** Cao, H. (Univ. of California, Los Angeles, CA (US)); McDermott, D.B.; Luhmann, N.C. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4P36.

The beneficial effects of high efficiency and Doppler upshift from cyclotron autoresonance while using only a low energy beam can be obtained by incorporating a dielectric liner along the inner walls of the Gyro-TWT tube. The dielectric slows the wave so that a wave with $\omega/\kappa \approx c$ can be stably exited. The authors' first Cherenkov CARM is an oscillator. The cavity's radius and length are 0.635 cm and 17.78 cm, respectively. An alumina liner with an outer radius of 0.635 cm an inner radius of 0.476 cm and a length of 17.78 cm has been obtained from Coors. A 12.9 GHz TE_{11} wave will be excited by a 75 kV electron beam with an α of 1 within a magnetic field of 3.4 kG. The Doppler upshift is 55%. They successfully tested a magnetic kicker to transform the purely axial velocity of a pencil beam into the helical beam required for the gyro-tube. The electron beam was passed through an iron ring within the magnetic field. The ring produces a non-adiabatic depression in the field. The $v_z B_r$ azimuthal force produces a transverse velocity. To test the helical beam in a controlled experiment, the transformed 500 kW beam was directed through a gyrotron cavity with a radius and length of 0.871 cm and 8.71 cm respectively. 40kW has been emitted at 10.5 GHz from the cavity's TE_{11} mode. Monochromatic second harmonic emission occurs at a power level of 1kW at 16.9 Ghz, which corresponds to the TE_{21} mode.

8904 **Theory of the high-power magnetron magnetron with intense electron flow.** Stark, R. (Naval Surface Warfare Center, Silver Spring, MD (US)); Uhm, H. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4P32.

The magnetron has attracted much attention lately as a means of efficiently generating high-power electromagnetic radiation. Although there are successful applications of the magnetron, including the microwave oven, the theory of the magnetron is very primitive and ad hoc. A self-consistent theory of this device is essential for the development of a high power (>GW) high-efficiency magnetron. The major difficulties in developing such a description are the presence of the anode resonators and the intense self field of the electron flow at the cathode. Previously, in an effort to develop the first self-consistent theory of the magnetron, a linear stability analysis of the extraordinary mode in both a planar and a cylindrical magnetron was performed, using a macroscopic cold-fluid model for the electron flow. A closed analytic dispersion relation was found for each geometry in the limit of a tenuous electron flow. In this work, the authors have lifted this tenuous flow restriction by numerically solving the eigen-differential equation characterizing an intense electron flow at the cathode. In this way, the magnetron behavior over a wide range of physical parameter is explored.

8905 **Resonant photopumping of a neon lasant plasma by a sodium pump plasma.** Young, F.C. (Naval Research Lab., Washington, DC (US)); Apruzese, J.P.; Burkhalter, P.G.; Cooperstein, G.; Davis, J.; Mosher, D.; Ottinger, P.F.; Scherrer, V.E.; Stephanakis, S.J.; Mehlman, C. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5A8.

Resonant photopumping of heliumlike neon by helium like sodium is being investigated to extend this pumping technique to the soft x-ray region. In the Na-pump/Ne-lasant system, the $1s^2$-$1s2p^1P_1$ line of Na X at 11.0027 A differs by 2 parts in 10^4 from the $1s^2$-$1s^4p^1P_1$ line of Ne 1X at 11.0003 A. This wavelength difference corresponds to about one Doppler width at the sodium plasma temperatures (200-500 eV) required for strong Na X pump radiation. Sodium line radiation of sufficient power irradiating a properly prepared neon plasma will cause overpopulation of the Ne 1X n = 4 singlet level leading to lasing in the 4-3, 4-2, and possibly 3-2 singlet transitions. Experimentally, the current pulse from the NRL Gamble-II generator is used to produce side-by-side z-pinch plasmas of sodium fluoride (NaF) and neon. The discharges are viewed radially with x-ray diagnostics including time-integrated pinhole cameras, time-resolved x-ray diodes, and a time-integrated curved-crystal spectrograph. Measurements of the neon plasma indicate that a discharge current of about 200 kA is required to produce a neon lasant with a dominant heliumlike ground-state population. For fluorescence experiments, appropriate neon lasant conditions (density of about 10^{18} cm^{-3} and temperature of 50-100 eV) must be produced at the time of the intense sodium pump-line radiation. Fluorescence is demonstrated by observing enhancement of the 4-1 line (He-γ) from the neon plasma relative to the 3-1 line (He-γ) when the neon is pumped by sodium. An increase in this γ-to-β ratio of 25% has been observed when the sodium pump radiation is present. The results of recent experiments are reported, and their implications for future experiments are discussed.

8906 **History of the Z-pinch.** Lovberg, R.H. (UCSD, La Jolla, CA (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6H.

The plasma Z-Pinch occupies a unique position in the history of controlled fusion research as the first confinement and heating scheme to be tried experimentally. In contrast to the sophistication of programs being conducted today, in which extensive theoretical and experimental forces are in close collaboration, early pinch experiments were designed on quite elementary theoretical grounds. Indeed, these systems and the results from them provided the focus for much of the rapid development of theoretical plasma physics and magnetohydrodynamics during the 1950's. In comparison to present programs, these early experiments had the considerable advantage of small size and minimal managerial encumbrance. After nearly three decades of abandonment because of difficulties with

MHD instabilities, the Z-pinch is arising once again in a new incarnation characterized by microscopic size and time scales, and very high density. Uniquely in the history of the pinch, the new experimental surprises seem encouraging, rather than discouraging, to the goal of thermonuclear fusion.

8907 Ion acceleration in an unmagnetized reflex triode configuration. Stringfield, R. (Los Alamos National Lab., Los Alamos, NM (US)); Begay, F.; Morgan, G.; Wheat, R.; Yates, M.A. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6B2.

The authors observed energetic ions propagating downstream of an unmagnetized relativistic reflex triode. The configuration was driven by an electrical power pulse of 1.0-2.5 MV, 60-90 kA, and 70 ns FWHM duration. The ion source was a 6 micron thick aluminized mylar anode foil, coated with LiD or LiH powders held in an acrylic matrix. Two cathode diameters, 2 cm and 6.25 cm, were used. Deuterons and protons were detected using carbon, copper, chromium, and zinc nuclear activation threshold techniques. Time resolved ion measurements were performed with Faraday cup charge collectors. A spatially resolved scintillation detector recorded the radiation pattern of activation targets. Propagation of the beam to distances beyond 2 meters was examined. The effect of anode cathode spacing, target distance, and anode preparation on the particle beam production was also examined. Both ion time-of-flight and threshold activation suggest ion energies which exceed the primary diode energy, with peak proton energies above 14 MeV. The spatial scintillation detector has indicated that the beam is divergent, with a central region of higher density having a divergence half-angle of less than 10 degrees, directed off axis approximately 10 degrees. Deuteron and proton fluxes of 10^{12}-10^{13} ions were measured by activation and charge collector data.

8908 The simulated behavior of the magnetically insulated transmission line oscillator. Marder, B.M. (Sandia National Lab., Albuquerque, NM (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5B4.

The magnetically insulated transmission line oscillator (MILO) is a high-power microwave generating device whose behavior has been investigated experimentally and by numerical simulation. This paper describes MILO operation and its dependence on various parameters as predicted by these simulations. The predictions are compared with both experimental data and linear theory. The following areas are examined: applied voltage, load impedance, and region of electron emission; cavity depth, vane spacing, anode-cathode gap, vane width, and number of cavities; and single and multiple cavity RF power extraction. It has been found that the so called "pi mode" is, in fact, degenerate for this open-ended device, and that, for certain parameters, it can split into two simultaneously running modes with very similar amplitude and frequency but different spatial structure. This had not been anticipated by analytic theory and seems to be a consequence of finite length. The effects of this split, some of which are quite subtle, have been observed experimentally. An algorithm for extracting RF power from this two-dimensional simulated MILO is described and results are presented.

8909 Sodium source development for pulsed power driven, photopumped NA/NE x-ray laser experiments. Burkhalter, P.G. (Naval Research Lab., Washington, DC (US)); Cooperstein, G.; Mosher, D.; Ottinger, P.F.; Scherrer, V.E.; Stephanakis, S.J.; Young, F.C.; Hinshelwood, D.D.; Mehlman, G.; Welch, B.L. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5A9.

A sodium plasma source is being developed for a resonant photopumping x-ray laser scheme in which the 11A $1s^2$ - 1s2rho $^1P_1$ line in heliumlike Na X is used to pump the Ne IX n=4 singlet level. In their experiment the NRL Gamble II generator is used to produce two z-pinch plasmas in a side-by-side geometry. The sodium plasma is produced on axis and conducts the full 1 MA machine current. A fraction of this current returns through a neon gas puff located 5 cm from the sodium. This separation is determined by the need to prevent the plasmas from mixing and the need to have each plasma's azimuthal magnetic field as symmetric as possible. A minimum separation is desirable to increase coupling efficiency. To improve the pump source, a more confined source of pure sodium involving a coaxial plasma gun is being developed. They are currently studying both the operation of this source on a test stand and implosions of the resulting plasma on Gamble II. In initial experiments aluminum is substituted for sodium. Test stand diagnostics include photodiodes, witness plates, and current monitors designed to investigate the early motion of the annular plasma. Results from test stand and Gamble II experiments with both aluminum and sodium, as well as sodium handling techniques, are presented.

8910 Proton beam focusing with a radial applied B-field ion diode on PBFA II. Johnson, D.J. (Sandia National Labs., Albuquerque, NM (US)); Lockner, T.R.; Leeper, R.J.; Maenchen, J.E.; Ruiz, C.; Stygar, W.A.; Mehlhorn, T.A.; Rosenthal, S.E.; Coats, R.S.; Quintenz, J.P. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract AC04-76DP00789. (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6B1.

Ion beam focusing experiments have been performed on PBFA II using a 15-cm-radius version of an ion diode used on PROTO I. A pair of B-field coils located in the cathodes supply the 2 T axial B-field used to insulate the 1.7 cm anode-cathode gap from electron loss. Anode B-field coils adjust the level of magnetic insulation along the anode surface and control the canonical angular momentum of the bean originating from surface flashover anode sources. The diode uses a cylindrical, 12.5-cm-radius beam current neutralizing gas cell with 2-μm-thick mylar window and 3 torr argon gas fill. Diagnostic measurements presented include the total current, ion current, and voltage at the diode, nuclear activation, witness plate damage, proton beam energy spectrum, and spatial beam profiles at 4 and 0 cm radius.

8911 Plasma opening switch experiments on supermite. Mendel, C.W. (Sandia National Labs., Albuquerque, NM (US)); Quintenz, J.P.; Rosenthal, S.E.; Savage, M.E. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract AC04-76DP00789. (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P23.

Experiments using plasma opening switches with fast field coils and plasmas injected on slow magnetic fields are described. Data showing the measurement of the field penetration into the volume that initially held the plasma fill will be shown. Assuming the plasma is mostly pushed back from the coil, rather than being penetrated by the magnetic field allows the density to be calculated, and gives densities of a few times 10^{13} cm^{-3} for our usual operating range. The data makes it clear that the switch is open well before the initial plasma volume is completely penetrated by the magnetic fields. Additional measurements relating to the magnetic field penetration distance and physical penetration mechanism are presented. Other data presented show a magnetic insulation problem which must be solved before very large voltage multiplication can be accomplished with sufficient switch efficiency.

8912 Status and directions for implicit PIC simulation. Hewett, D.W. (Lawrence Livermore National Lab., Livermore, CA (US)); Friedman, A.; Mason, R.J.; Barnes, D.C. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract W-7405-ENG-48. (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5D8-9.

The PIC method has proven to be a most versatile algorithm for modeling plasma kinetic behavior. The method's capabilities have

been further expanded by the recent development of implicit PIC algorithms. New codes based on these algorithms now routinely run a variety of problems exploiting the increased flexibility in time step selection. The authors review the distinction between the two major types of algorithms (implicit-moment and direct-implicit) and the capabilities of codes based on them. As with any new method, utility expands with experience. Some of the new directions for expansion now being explored include non-cartesian geometry, relativistic formalisms, mixtures of fluid and kinetic representations, and multiscale time integration.

8913 **q measurements during sawtooth oscillations in a low q tokamak.** Moyer, R.A. (Department of Physics, University of Wisconsin, Madison, Wisconsin 53706 (US)); Goetz, J.A.; Dexter, R.N.; Prager, S.C. *Physics of Fluids B: Plasma Physics (USA),* 1(11): 2139-2141 (Nov 1989).

The central safety factor during a sawtooth oscillation in material limiter tokamak discharges (scrapeoff plates inserted to the separatrix) in the TOKAPOLE II poloidal divertor tokamak [Phys. Rev. Lett. **49**, 734 (1982)] is measured to be significantly less than 1 (approximately 0.7) during a sawtooth oscillation. This result is identical to that observed earlier in the same device in magnetic limiter discharges. Thus the presence of scrapeoff plasma beyond the divertor separatrix is not responsible for the absence of total reconnection.

8914 **Theory of neoclassical resistivity-gradient-driven turbulence.** Kwon, O.J. (Institute for Fusion Studies, The University of Texas at Austin, Austin, Texas 78712 (US)); Diamond, P.H.; Hahm, T.S. *Physics of Fluids B: Plasma Physics (USA),* 1(11): 2172-2180 (Nov 1989).

It is shown that rippling instabilities can tap the density gradient expansion free-energy source through the density dependence of the neoclassical resistivity. Linear analyses show that the region where neoclassical rippling modes are significantly excited extends from the edge of the plasma to the region where $\nu_{*e} \leq 1$. Since these modes are nondispersive, diamagnetic effects are negligible in comparison to the nonlinear decorrelation rate at saturation. Thus the relevant regime is the "strong turbulence" regime. The turbulent radial diffusivities of the temperature and the density are obtained as eigenvalues of the renormalized eigenmode equations at steady state. The density gradient acts to enhance the level of turbulence, compared to that driven by the temperature gradient alone. The saturated turbulent state is characterized by current decoupling, the breakdown of Boltzmann relation, a radial mode scale of density fluctuations exceeding that of temperature fluctuations, implying that density diffusivity exceeds temperature diffusivity, and that density fluctuation levels exceed temperature fluctuation levels. Magnetic fluctuation levels are negligible.

8915 **Numerical simulation of the reversed field pinch dynamo effect in the quasilinear, mean field equilibrium limit.** Caramana, E.J. (Los Alamos National Laboratory, Los Alamos, New Mexico 87545 (US)). *Physics of Fluids B: Plasma Physics (USA),* 1(11): 2186-2193 (Nov 1989).

In this paper numerical simulations are presented of the reversed field pinch (RFP) dynamo effect utilizing the resistive magnetohydrodynamic (MHD) equations in the quasilinear approximation. In addition, a mean field equilibrium magnetic field configuration is constructed in cylindrical geometry by dropping inertia on the symmetric radial component of the velocity field. Results are obtained for a variety of operating conditions: flat-top current, current ramp-up, and ramp-down. It is found that the Alfven time, although present in the equations describing the perturbed quantities, is not important on the long resistive run time; the result is a three-dimensional Ohmic equilibrium with symmetric mean toroidal magnetic field reversal. Using these results, and in view of recent RFP experimental data, a simple correspondence between global MHD behavior in the RFP and the tokamak is given.

8916 **Toroidal effects on m=2 feedback.** Hender, T.C. (UKAEA/Euratom Fusion Association, Culham Laboratory, Abingdon, Oxon, United Kingdom (GB)); Cowley, S.C. *Physics of Fluids B: Plasma Physics (USA),* 1(11): 2194-2200 (Nov 1989).

Toroidal calculations on m=2 magnetic feedback are presented. These calculations are performed using a coupled Δ' formulation and show that the feedback can have a pronounced effect on the sideband (m=1 and 3) content.

8917 **Damping of lower hybrid waves by low-frequency drift waves.** Krall, N.A. (Krall Associates, Del Mar, California 92014 (US)). *Physics of Fluids B: Plasma Physics (USA),* 1(11): 2213-2216 (Nov 1989).

The conditions under which a spectrum of lower hybrid drift waves will decay into low-frequency drift waves (LFD) are calculated. The purpose is to help understand why lower hybrid drift waves are not seen in all field-reversed configuration (FRC) experiments in which they are predicted. It is concluded that if there is in the plasma a LFD wave amplitude above a critical level, lower hybrid waves will decay into low-frequency drift waves. The critical level required to stabilize TRX-2 [Phys. Fluids **30**, 1497 (1987)] is calculated and found to be reasonably consistent with theoretical estimates.

8918 **Narrow Raman spectra: The competition between collisional and Landau damping.** Drake, R.P. (Lawrence Livermore National Laboratory, Livermore, California 94550 (US)); Williams, E.A.; Young, P.E.; Estabrook, K.; Kruer, W.L.; Montgomery, D.S.; Baldis, H.A.; Johnston, T.W. *Physics of Fluids B: Plasma Physics (USA),* 1(11): 2217-2223 (Nov 1989). DOE Contract W-7405-ENG-48.

Narrow Raman spectra can be produced when the collisional damping rate becomes comparable to the homogeneous growth rate for stimulated Raman scattering (SRS). Landau damping limits the SRS spectrum at short wavelength, and collisional damping can limit it at long wavelength through the variation of the damping rate with plasma density. Data are shown to demonstrate this effect for the first time, from experiments in which constant-intensity pulses of 0.35 μm light irradiated 3 μm thick CH targets at intensities up to 2×10^{14} W/cm^2. The observed spectra have a peak wavelength, spectral width, spectral shape, and shift of the peak in time that are consistent with the anticipated effects of damping. Reduction of the emission from the plasma to near thermal levels at heavily damped frequencies is also demonstrated. In addition, the application of two specific models of SRS to these data is discussed.

8919 **Plasma flow measurements along the presheath of a magnetized plasma.** Chung, K. (Plasma Fusion Center, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139 (US)); Hutchinson, I.H.; LaBombard, B.; Conn, R.W. *Physics of Fluids B: Plasma Physics (USA),* 1(11): 2229-2238 (Nov 1989).

Plasma flow measurements in the presheath have been performed using two types of directional electric "Mach" probes, in the PISCES facility at UCLA [J. Nucl. Mater. **121**, 277 (1984)]. A fast scanning versatile probe combination has been developed, which operates simultaneously as a "magnetized" Mach probe, an "unmagnetized" Mach probe (with characteristic probe size greater than and smaller than ion gyroradius, respectively), and an emissive probe. Presheaths have been investigated by inserting a small object at the center of the plasma column. Variations in plasma flow velocity, density, and potential along the presheath have been deduced by fluid and kinetic theories. A comparison is made between Mach numbers obtained from the magnetized probe and the unmagnetized probe. Incorporation of shear viscosity of order $\sim 0.5 n m_{iD\perp}$ in the cross-field transport along the presheath seems best to model the results. The cross-field diffusivity ($D_\perp$) is found to scale approximately proportional to $B^{-1/2}$, with magnitude about 4× larger than Bohm in the PISCES plasma. The effect of an electrical bias applied to the object on the presheath characteristics is discussed.

8920 **Kelvin–Helmholtz vortex formation and particle transport in a cross-field plasma sheath. I. Transient behavior.** Theilhaber, K. (Plasma Theory and Simulation Group, Electronics Research Laboratory, University of California, Berkeley, California 94720 (US)); Birdsall, C.K. *Physics of Fluids B: Plasma Physics (USA),* 1(11): 2244-2259 (Nov 1989).

The time-dependent behavior of a transversely magnetized, two-dimensional plasma–wall sheath has been studied through particle simulations, with the aim of modeling plasma behavior in the vicinity of the limiters and walls of magnetized plasma devices. The model assumes a magnetic field perfectly parallel to the confining surfaces. The simulations have shown that the cross-field sheath between a wall and a plasma is a self-sustaining turbulent boundary layer, with

strong potential fluctuations and anomalous particle transport. The driving mechanism for this turbulence is the Kelvin–Helmholtz instability, which arises from the sheared particle drifts created near the wall. In this paper, the transient behavior leading to the turbulent steady state is presented, and the processes of linear growth, vortex saturation, and vortex coalescence are examined. An analytic model for the boundary Kelvin–Helmholtz instability is derived and shown to correctly predict the growth rates of the long-wavelength modes. In a companion paper, the steady-state structure and behavior of the cross-field sheath will be discussed in detail.

8921 Kelvin–Helmholtz vortex formation and particle transport in a cross-field plasma sheath. II. Steady state. Theilhaber, K. (Plasma Theory and Simulation Group, Electronics Research Laboratory, University of California, Berkeley, California 94720 (US)); Birdsall, C.K. *Physics of Fluids B: Plasma Physics (USA),* 1(11): 2260-2272 (Nov 1989).

The steady-state behavior of the magnetized plasma–wall sheath has been studied through two-dimensional particle simulations, which have shown that the sheath maintains itself in a strongly nonlinear, turbulent equilibrium, continuously driven by the edge Kelvin–Helmholtz instability. The sheath assumes a thickness of order $l_x \sim 5\rho_i$, and maintains large, long-lived vortices, with amplitudes $\delta\phi \sim 2.5T_i/e$, which drift parallel to the wall at half the ion thermal velocity. The sheath also maintains a large, spatially averaged potential drop from the wall to the plasma with $\Delta\phi \approx -2T_i/e$, opposite in sign to that of the unmagnetized sheath. Accompanying the long-wavelength vortices are shorter-wavelength fluctuations, which induce an anomalous cross-field transport, scaling in accordance to Bohm diffusion when $\omega_{pi} \geq 2\omega_{ci}$. At lower densities, $\omega_{pi} < 2\omega_{ci}$, the diffusion coefficient has an additional factor, proportional to the density. These results permit the modeling of the cross-field sheath by a simple effective boundary condition.

8922 The frictional force in counterstreaming plasmas. Bardsley, J.N. (Lawrence Livermore National Laboratory, Livermore, California 94550 (US)); Boercker, D.B.; Penetrante, B.M. *Physics of Fluids B: Plasma Physics (USA),* 1(11): 2283-2285 (Nov 1989). DOE Contract W-7405-ENG-48.

The purpose of this Brief Communication is to calculate the frictional force between two fully ionized plasmas that are moving with respect to one another. Such a calculation is relevant to the expansion of explosion debris into a preionized gas, and to the heating or fueling of a fusion reactor by plasma injection. When the charge densities of the two plasmas are of smilar magnitude, the frictional force is significantly different from that appropriate to the stopping of test particles or to the calculation of electrical conductivity.

8923 The effect of enhanced plasma waves on Thomson scattering with a high-frequency probe laser. Drake, R.P. (Lawrence Livermore National Laboratory, Livermore, California 94550 (US)). *Physics of Fluids B: Plasma Physics (USA),* 1(11): 2291-2293 (Nov 1989). DOE Contract W-7405-ENG-48.

McIntosh *et al.* [Phys. Rev. Lett. **57**, 337 (1986); Phys. Fluids **29**, 3451 (1986)] have reported experiments in which electron-plasma waves, attributed to simulated Raman scattering, were detected by Thomson-scattering measurements. Based on threshold considerations and sample calculations, Simon and Short have argued [Phys. Fluids **31**, 3371 (1988)] that a model of enhanced electron-plasma waves, driven by an electron beam in the plasma, might explain the data. In the present Brief Communication Thomson scattering from plasma waves driven by an electron beam is analyzed. It is shown that each extremum of the angle or frequency of the observed scattering can be independently used to infer the energy of the electron beam. For the present Thomson-scattering data, the inferred energies differ in both magnitude and time dependence, implying that the enhanced-plasma-wave model is inconsistent with the data.

8924 TFTR neutral beam injected power measurement. Kamperschroer, J.H. (Princeton Plasma Physics Laboratory, Princeton University, Princeton, NJ (USA)); Grisham, L.R.; Dudek, L.E.; Gammel, G.M.; Johnson, G.A.; Kugel, H.W.; Lagin, L.; O'Connor, T.E.; Shah, P.A.; Sichta, P.; and others. *Review of Scientific Instruments (USA),* 60(11): 3377-3385 (Nov 1989).

Energy flow within TFTR neutral beamlines is measured with a waterflow calorimetry system capable of simultaneously measuring the energy deposited within four heating beamlines (three ion sources each), or of measuring the energy deposited in a separate neutral beam test stand. Of the energy extracted from the ion source on the well-instrumented test stand, 99.5±3.5% can be accounted for. When the ion deflection magnet is energized, however, 6.5% of the extracted energy is lost. This loss is attributed to a spray of devious particles onto unmonitored surfaces. A 30% discrepancy is also observed between energy measurements on the internal beamline calorimeter and energy measurements on a calorimeter located in the test stand target chamber. Particle reflection from the flat plate calorimeter in the target chamber, which the incident beam strikes at a near-grazing angle of 12°, is the primary loss of this energy. A slight improvement in energy accountability is observed as the beam pulse length is increased. This improvement is attributed to systematic error in the sensitivity of the energy measurement to small fluctuations in the supply water temperature. An overall accuracy of 15% is estimated for the total power injected into TFTR. Contributions to this error are uncertainties in the beam neutralization efficiency, reionization and beam scrape-off in the drift duct, and fluctuations in the temperature of the supply water.

8925 Computed circular polarization of line emissions for Δn=1 transitions between highly excited states of hydrogenic ions in tokamak plasmas. Huang, L.K. (Department of Physics and Astronomy, The Johns Hopkins University, Baltimore, Maryland 21218 (US)); Wroblewski, D.; Finkenthal, M.; Moos, H.W.;. *Physical Review [Section] A: General Physics (USA),* 40(9): 5224-5231 (1 Nov 1989).

Circular polarization of spectral lines due to Δn=1 transitions between highly excited states (n=6–8) of low-Z hydrogenic ions (C VI and O VIII) has been computed under tokamak plasma conditions. The numerical model includes relativistic corrections, the Zeeman effect, the motional Stark effect, and Doppler broadening. The motional Stark effect in spectral line profiles is negligible because of Doppler broadening. The Zeeman effect is described by the intensity-averaged splitting factor, which is equal to unity and independent of the Stark effect for all Rydberg lines (provided the n shells are well separated). The circular polarization of the line is proportional to the component of the magnetic field in the direction of the observation direction. An analytical expression for the polarization, as a function of the intensity-averaged Zeeman splitting and a characteristic linewidth, is formulated by fitting the numerical results obtained for a variety of plasma conditions and spectral lines.

8926 Multiple-fluid models for plasma wake-field phenomena. Rosenzweig, J.B. (Fermi National Accelerator Laboratory, Batavia, Illinois 60510 (US));. *Physical Review [Section] A: General Physics (USA),* 40(9): 5249-5255 (1 Nov 1989). DOE Contract W-31-109-ENG-38.

In this paper we present various treatments of plasma wake-field phenomena which employ multiple-fluid models. These models generalize the one-dimensional, nonlinear, relativistic single-fluid model which has been used extensively in previous plasma wake-field calculations. Using a two-fluid model, we discuss the interaction of a low-energy continuous electron beam with wake-field-generated plasma waves. The phenomena of continuous-beam modulation and wave period shortening are discussed. The relationship between these effects and the two-stream instability is also examined. Also, using a three-fluid model, effects due to plasma electron temperature in nonlinear plasma wake-fields are examined and compared to previous work. Finally, the consequences of ion motion induced by large-amplitude electron plasma waves are calculated by including the fluid behavior of the ions.

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Refer also to citation(s) 7909, 7911, 8206, 8207, 8208, 8230, 8261, 8853, 8854, 8855, 8856, 8857, 8859, 8862, 8863, 8865, 8866, 8867, 8868, 8869, 8871, 8872, 8873, 8875, 8877, 8879, 8880, 8882, 8883, 8884, 8886, 8887, 8889, 8890, 8892, 8893, 8895, 8897, 8898, 8903, 8904, 8905, 8906, 8907, 8908, 8910, 8911

8927 (CONF-891007–99) **Two dimensional LOCA [loss-of-coolant accident] analysis for fusion reactors.** Attaya, H.; Gohar, Y. Argonne National Lab., IL (USA). Oct 1989. 6p. Sponsored by

U.S. DOE Energy Research. DOE Contract W-31109-ENG-38. From 13. IEEE symposium on fusion engineering; Knoxville, TN (USA); 2-6 Oct 1989. Order Number DE90003768. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Two dimensional loss-of-coolant accident (LOCA) analysis has been made for the inboard shield of a US design proposed for the International Thermonuclear Experimental Reactor (ITER). The finite element heat transfer code TOPAZ2D has been used to model the inboard shield. It is assumed that the plasma continues to operate for 10 seconds after the onset of LOCA. During this time the heat source consists of the heat flux on the first wall (FW) tiles, the nuclear heating, and the radioactive decay heat. After the 10 seconds, the decay heat becomes the only heat source. The magnets are assumed intact during and after the accident and heat is radiated from the shield to the magnet's thermal shield which is at 70°K. The temperature response of the shield has been calculated up to 12.8 hours after the LOCA starts. The results show that the temperature everywhere in the shield is tolerable. The maximum temperature of the back of the shield, which is made of lead, reaches 41°C at the end of the 10 seconds plasma-on period. The maximum temperature of the first wall reaches 520°C at 7.5 hour from shutdown. After that it starts to decrease slowly. 8 refs., 5 figs.

8928 (GA-A–19743) **Neutron shielding system for the DIII-D research facility.** Anderson, P.M.; Phelps, R.D.; Venkatesh, M.C. General Atomics, San Diego, CA (USA). Dec 1989. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-89ER51114. (CONF-891007–107: 13. IEEE symposium on fusion engineering, Knoxville, TN (USA), 2-6 Oct 1989). Order Number DE90004097. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

The research program for the DIII-D tokamak has been expanded to include experiments using deuterium plasmas and deuterium neutral beams. In the absence of additional shielding, the increased radiation levels associated with these experiments are calculated to exceed the DOE guidelines of 20 mr/yr above background at the site boundary. To minimize overall exposure, a shielding system has been installed at the DIII-D facility to completely surround the machine pit area inside the building. 5 refs., 5 figs.

8929 (GA-A–19745) **Modeling energy output of inertial storage devices for the DIII-D tokamak.** Torre, W.V.; Petersen, P.; Kellman, A. General Atomics, San Diego, CA (USA). Dec 1989. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-89ER51114. (CONF-891007–108: 13. IEEE symposium on fusion engineering, Knoxville, TN (USA), 2-6 Oct 1989). Order Number DE90004096. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

The DIII-D fusion experiment utilizes two large motor-generator sets for supplying energy to the toroidal and poloidal field coils of the tokamak. One generator has an energy capability of 2250 MJ and the other has 794 MJ. This paper documents the development of a computer program which models the energy requirements of a fusion tokamak and compares them to the limitations of a large motor-generator set. The program models the energy requirements of the magnetic confinement coils and also determines the current (Amperes) requirements (as a function of time) reflected to the generator depending on the physics parameters under study for the plasma. This program is used on a daily basis and by optimizing for minimum energy usage, a significant annual cost savings is realized. 3 refs., 2 figs., 1 tab.

8930 (GA-A–19759) **Measurement of neutral beam profiles on DIII-D inner wall armor tiles using scanning infrared optics.** Lee, R.; Colleraine, A.P.; Hong, R.; Kim, J.; Phillips, J.; Wight, J. General Atomics, San Diego, CA (USA). Dec 1989. 4p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-89ER51114. (CONF-891007–105: 13. IEEE symposium on fusion engineering, Knoxville, TN (USA), 2-6 Oct 1989). Order Number DE90004099. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Characteristic thermal footprints made by energetic neutral beams on the inner wall graphite tiles of the DIII-D tokamak have been examined using infrared scanning optical detectors. Horizontal and vertical neutral beam widths are measured from the IR scanner images and the corresponding divergence angles are estimated and compared to those obtained from calorimetry techniques. Neutral beam injected power is estimated using a one-dimensional heat flow model and temperature data from an IR scanner. 13 refs., 5 figs.

8931 (GA-A–19760) **Control system upgrade for the DIII-D neutral beamline.** Gilgallon, J.J.; Phillips, J. General Atomics, San Diego, CA (USA). Dec 1989. 3p. Sponsored by U.S. DOE Energy Research. DOE Contract AC03-89ER51114. (CONF-891007–106: 13. IEEE symposium on fusion engineering, Knoxville, TN (USA), 2-6 Oct 1989). Order Number DE90004098. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

After a decade of operation, the DIII-D tokamak neutral beamline control system has been upgraded using a new medium-sized programmable logic controller (PLC). Its primary function is direct and automatic control of the vacuum, gas, and water cooling systems. In addition, the control instrumentation (CI) PLC provides an interface to the main beam control computer and other local control devices. The new PLC features high-density, optically isolated inputs and outputs and intelligent analog input/output (I/O). The PLC is concentrated in the CI station located near the neutral beamline tank. Remote, on-line, optically isolated programming and diagnostics are achieved through the use of inexpensive, RS232C modems and a central programming station. Independent, peer, or hierarchical operation, future graphics capability on a fast network and expansion capability were goals of this design change. Automation, enhanced capability, and flexibility of control will be discussed. 2 refs., 2 figs.

8932 (INIS-mf–11516) **Vibrational excitation in a hydrogen volume source.** Eenshuistra, P.J. Amsterdam Univ. (Netherlands). 26 Apr 1989. 120p. Order Number DE90705961. Available from NTIS (US Sales Only), PC A06/MF A01 - OSTI.

In this thesis the complex of processes which determines the D^- or H^- density in a volume source, a hydrogen discharge, is studied. D^- beams are of interest for driving the current of a fusion plasma in a TOKAMAK. Densities of vibrationally excited molecules, of H atoms, and of metastable hydrogen molecules were determined using Resonance-Enhanced MultiPhoton Ionization (REMPI). An experiment in which vibrationally highly excited molecules are formed by recombinations of atoms in a cold metal surface, is described. The product and destruction of vibrationally excited molecules and atoms in the discharge is discussed. The vibrational distribution for $3 \leq v \leq 5$ is strongly super-thermal. The analysis with a model based on rate equations, which molecules are predominantly produced by primary electron excitation of hydrogen molecules and deexcited upon one wall collision. The atom production is compatible with dissociation of molecules by primary electrons, dissociation of molecules on the filaments, and collisions between positive ions and electrons. The electrons are predominantly destroyed by the recombination on the walls. Finally, the production and destruction of H^- in the discharge are discussed. The density of H^- in the plasma, the electron density and temperature were determined. H^- extraction was measured. The ratio of the extracted H^- current and the H^- density in the plasma gives an indication of the drift velocity of H^- in the plasma. This velocity determines the emittance of the extracted beam. It was found that the H^- velocity scales with the square root of the electron temperature. The measured H^- densities are compatible with a qualitative model in which dissociative attachment of plasma electrons to vibrationally excited molecules is the most important process. 136 refs., 39 figs., 10 tabs.

8933 (JAERI-M–89-105) **Design of JT-60U ICRF launcher.** Saigusa, Mikio (Japan Atomic Energy Research Inst., Naka, Ibaraki (Japan). Naka Fusion Research Establishment); Kimura, Haruyuki; Fujii, Tsuneyuki; Kobayashi, Noriyuki; Moriyama, Shin-ichi; Annoh, Katsuto; Ogawa, Yoshiro; Shinozaki, Shin-ichi; Terakado, MaJapan Atomic Energy Research Inst., Tokyo (Japan). Aug 1989. 37p. (In Japanese). Order Number DE90733145. Available from NTIS (US Sales Only), PC A03/MF A01.

JT-60U ICRF launcher is designed based on the measurement of electromagnetic field profile in front of a test launcher and the calculation of coupling properties. The coupling code was made for the antenna array whose each antenna element was recessed in a metal box and was a trombone shape. The image current induced on the metal separator degrates the loading resistance for only in-phase. The loading resistance of designed antenna is predicted to be over 2 Omega for out of phase in a H-mode like density profile

with the distance of 6 cm between the sparatrix surface and the launcher. (author).

8934 (JAERI-M–89-115) **The current profile modification in JT-60 pellet injection experiments.** Yoshino, Ryuji (Japan Atomic Energy Research Inst., Naka, Ibaraki (Japan). Naka Fusion Research Establishment). Japan Atomic Energy Research Inst., Tokyo (Japan). Sep 1989. 14p. Order Number DE90733138. Available from NTIS (US Sales Only), PC A03/MF A01.

The current profile modification by the pellet injection has been numerically investigated on JT-60 Tokamak using the diffusion equation of the poloidal magnetic field. The results suggests $q(0)<1$ during the sawtooth-free phase obtained by high power NB heating of pellet injected plasmas. (author).

8935 (Juel–2280) **Neutron irradiation of non-metallic first wall materials for fusion devices.** Koizlik, K.; Hoven, H.; Linke, J.; Nickel, H.; Wallura, E. Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Inst. fuer Reaktorwerkstoffe. May 1989. 47p. Order Number DE90732692. Available from NTIS (US Sales Only), PC A03/MF A01.

In ignited fusion plasmas, about 80% of the fusion energy will be transported to the first wall by an intense flux of energetic neutrons. Therefore the neutron induced changes of material properties and material damages have to be investigated for the first wall materials. Since a realistic fusion neutron source is not available so far IRW has set up a neutron irradiation program for non-metallic first wall materials in nuclear fission reactors. This report summarizes the fusion-relevant irradiation data from irradiation experiments that have been carried out during the development of the High Temperature Gas Cooled Reactor, the consequences for the new irradiation program, the test philosophy derived from these results, and the first irradiation experiments in this new series. (orig.).

8936 (LA-UR–89-3827) **Recent progress on the HESS [High Explosive Spheromak Source] experiment.** Mayo, R.M. (Los Alamos National Lab., NM (USA)); Barnes, D.C.; Freeman, B.; Henins, I.; Jarboe, T.R.; Platts, D. Los Alamos National Lab., NM (USA). [1989]. 4p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-36. (CONF-8911130–4: 11. US/Japan workshop on field-reversed configurations and compact toroids, Los Alamos, NM (USA), 7-9 Nov 1989). Order Number DE90003218. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The new objective of the Los Alamos spheromak program is to assess the use of magnetized plasmas as an energy transfer medium to accelerate material objects to hyper-velocities ($\gtrsim$ 20 km/s). In meeting this objective, we are committed to the subordinate goals of creating high field, long-lived spheromak discharges, examining the technical feasibility of employing High Explosives (HE) to compress seed spheromaks, and investigate the technical requirements involved in forming spheromaks by Mechanical Helicity Injection (MHI) using HE. This paper describes the recent efforts of the CTR-5, M-4, and M-6 groups at Los Alamos in assessing the feasibility of generating magnetic helicity by mechanical means in the High Explosive Spheromak Source (HESS) experiment. 3 refs., 3 figs.

8937 (LA-UR–89-3946) **Tritium and neutron measurements of a solid state cell.** Claytor, T.N.; Seeger, P.A.; Rohwer, R.K.; Tuggle, D.G.; Doty, W.R. Los Alamos National Lab., NM (USA). [1989]. 16p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-36. (CONF-8910313–1: NSF/EPRI workshop on anomalous effects in deuterated materials, Washington, DC (USA), 16-18 Oct 1989). Order Number DE90003657. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A solid state "cold fusion" cell was constructed to test for non-equilibrium fusion in a solid. The stimulus for the design was the hypothesis that the electrochemical surface layer in the Pons-Fleischmann cell could be replaced with a metal-insulator- semiconductor (MIS) barrier. Cells were constructed of alternating layers of palladium and silicon powders pressed into a ceramic form and exposed to deuterium gas at 110 psia resulting in a D/Pd ratio of 0.7. Pulses of current were passed through the cells to populate non-equilibrium states at the MIS barriers. One cell showed neutron activity and was found to have a large amount of tritium, other cells have produced tritium at a low rate consistent with neutron emission below the threshold of observability. The branching ratio for n/p has been about 1×10^{-9} in all the experiments where a substantial amount of tritium has been found. 11 refs., 9 figs., 2 tabs.

8938 (ORNL/ATD–23) **Stress analysis of the Princeton Plasma Physics Laboratory 1/2- x 1/2-in. shear/compression test fixture.** Blake, H.W. Oak Ridge National Lab., TN (USA). Oct 1989. 115p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004401. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

A finite element stress analysis was performed on a test fixture developed at the Princeton Plasma Physics Laboratory, which is utilized to test specimens of sheet insulating materials for the Compact Ignition Tokamak. The fixture is a newer version of one that had been previously analyzed. The new fixture was developed to test smaller-sized specimens that have had prior radiation exposure. The original fixture was utilized to test larger, unexposed specimens. The smaller specimens are of an appropriate size (0.5 x 0.5 in.) to fit into the test cell of a reactor. The internal stresses in the fixture and specimen were determined for two different conditions of loading. The uniformity of stress within the specimen as it related to the design of the fixture was examined. Two different geometrical shapes for the new fixture were analyzed. An assessment of the potential for specimen slippage is provided for a particular value of the coefficient of friction between the specimen and fixture. Results for a no-slip condition are also given.

8939 (ORNL/TM–11254) **ATF [Advanced Toroidal Facility]-2 studies.** Lyon, J.F.; Carreras, B.A.; Dominguez, N.; Dresner, L.; Hedrick, C.L.; Hirshman, S.P.; Lubell, M.S.; Lue, J.W.; Morris, R.N.; Painter, S.L.; Rome, J.A.; van Rij, W.I. Oak Ridge National Lab., TN (USA). Oct 1989. 34p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004380. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Design studies for a low-aspect-ratio, large next-generation stellarator, ATF-II, with high-current-density, high-field, stable NbTi/Cu helical windings are described. The design parameters are an average plasma radius of 0.52 m, a major radius of 2 m, and a field on axis of 4-5 T, with 10 to 15 MW of heating power. Such a device would be comparable in scope to other next-generation stellarators but would have roughly the same aspect ratio as the tokamaks without, however, the need for current drive to sustain steady-state operation. A number of low-aspect-ratio physics issues need to be addressed in the design of ATF-II, primarily compromises between high-beta capability and good confinement properties. A six-field-period Compact Torsatron is chosen as a reference design for ATF-II, and its main features and performance predictions are discussed. An integrated (beta capability and confinement) optimization approach and optimization of superconducting windings are also discussed. 36 refs., 13 figs., 2 tabs.

8940 (ORNL/TM–11255) **Near-term directions in the world stellarator program.** Lyon, J.F. Oak Ridge National Lab., TN (USA). Oct 1989. 26p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004381. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Interest in stellarators has increased because of the progress being made in the development of this concept and the inherent advantages of stellarators as candidates for an attractive, steady-state fusion reactor. Three new stellarator experiments started operation in 1988, and three more are scheduled to start in the next few years. In addition, design studies have started on large next-generation stellarator experiments for the mid-1990s. These devices are designed to test four basic approaches to stellarator configuration optimization. This report describes how these devices complement each other in exploring the potential of the stellarator concept and what main issues they will address during the next decade. 31 refs., 9 figs., 4 tabs.

8941 (PNL-SA–16980) **Phase evolution during neutron irradiation of commercial Fe-Cr-Mn alloys.** McCarthy, J.M.; Garner, F.A. Pacific Northwest Lab., Richland, WA (USA). Dec 1989. 9p. Sponsored by U.S. DOE Energy Research. DOE Contract AC06-76RL01830. (CONF-891204–9: 4. international conference on fusion reactor materials, Kyoto (Japan), 4-8 Dec 1989). Order Number DE90004113. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Earlier irradiation studies on simple Fe-Mn and Fe-Cr-Mn alloys in the annealed condition showed that these alloys exhibited a higher level of phase instability than do comparable Fe-Cr-Ni alloys. Contributing to this instability was the tendency of iron to segregate at microstructural sinks due to the operation of the inverse Kirkendall effect. This segregation, combined with the addition of various solutes and the application of typical thermomechanical treatments to produce the commercial alloys, added complexity to the phase evolution of Fe-Cr-Mn alloys. This complexity included the intergranular and intragranular precipitation of $M_{23}C_6$ carbide, alpha ferrite, and sigma. These phases can have detrimental effects on mechanical and corrosion properties. Provided that the phase transformations to sigma and carbides can be controlled, the commercial austenitic Fe-Cr-Mn alloys appear to be suitable starting compositions for the development of low activation alloys for service in fusion reactors. 9 refs., 7 figs., 1 tab.

8942 (PNL-SA–17021) **Microstructural explanation for irradiation embrittlement of V-15Cr-5Ti.** Gelles, D.S. (Pacific Northwest Lab., Richland, WA (USA)); Ohnuki, S.; Loomis, B.A.; Takahashi, H.; Garner, F.A. Pacific Northwest Lab., Richland, WA (USA). Nov 1989. 21p. Sponsored by U.S. DOE Energy Research. DOE Contract AC06-76RL01830. (CONF-891204–8: 4. international conference on fusion reactor materials, Kyoto (Japan), 4-8 Dec 1989). Order Number DE90004112. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Vanadium alloys are candidate materials for first wall fusion reactor applications based on low induced activity and heat resistant response. However, recent results have indicated that modest levels of neutron irradiation damage in V-15Cr-5Ti lead to severe degradation of mechanical properties. In order to explain the observed behavior, specimens of V-15Cr-5Ti have been examined by transmission electron microscopy following irradiation at 600°C to 14 dpa in the Fast Flux Test Facility (FFTF). The conditions examined included two heats of V-15Cr-5Ti with very different oxygen contents and, in one case, a section of a charpy specimen demonstrated to have very poor impact resistance. Specimens irradiated at 420 and 520°C were also examined to confirm density change measurements that indicated swelling levels as high as 2.5%. Following irradiation at 600°C, a complex microstructure was found that included a perfect dislocation network of line segments and loops, faulted loops, a high density of black spot damage and a high density of rod-shaped precipitates. Heat-to-heat variations did not appear to significantly alter these microstructural features; instead the density of large blocky precipitates, believed to be TiO_2, was found to have increased with increasing oxygen content. Only two of the specimens irradiated at 600°C contained voids, whereas none of the specimens irradiated at 420 or 520°C contained voids. 13 refs., 8 figs., 2 tabs.

8943 (PNL-SA–17297) **New materials options for nuclear systems.** Jones, R.H.; Bruemmer, S.M.; Garner, F.A.; Gelles, D.S. Pacific Northwest Lab., Richland, WA (USA). Nov 1989. 8p. Sponsored by U.S. DOE Energy Research. DOE Contract AC06-76RL01830. (CONF-891116–2: First international SAMPE symposium and exhibition on new materials and processes for the future, Chiba (Japan), 28 Nov - 1 dec 1989). Order Number DE90004116. Available from NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Development of new materials for nuclear reactor systems is continuing to produce options for improved reactor designs. Materials with reduced environment-induced crack growth is a key materials issue for the light water reactor (LWR) industry while the development of low activation ferritic, austenitic and vanadium alloys has been an active area for materials development for fusion reactor structural applications. Development of advanced materials such as metal matrix and ceramic matrix composites for reactor systems have received a limited amount of attention. 19 refs.

8944 (PNL-SA–17480) **Phase stability of a manganese-stabilized low-activation martensitic steel.** Griffin, R.D. (Wisconsin Univ., Madison, WI (USA)); Gelles, D.S.; Dodd, R.A.; Kulcinski, G.L. Pacific Northwest Lab., Richland, WA (USA). Dec 1989. 13p. Sponsored by U.S. DOE Energy Research. DOE Contract AC06-76RL01830. (CONF-891204–7: 4. international conference on fusion reactor materials, Kyoto (Japan), 4-8 Dec 1989). Order Number DE90004114. Available from NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The development of alloys with reduced long-life radioactivity has been incorporated into the goals of fusion materials development. One possible candidate alloy is Fe-12Cr-6.5Mn-1W-0.3V-0.1C, a manganese-stabilized martensitic steel. The phase stability of this steel has been investigated following neutron irradiation in the Fast Flux Test Facility at Richland, Washington, over a temperature range of 420 to 600°C to doses as high as 100 dpa. The microstructural response of the irradiated steel has been compared to that of the same alloy aged for 10,000 hours from 365 to 600°C. The only precipitate found following aging at 365 and 600°C was $M_{23}C_6$. After aging at 420 and 520°C, an Fe-Cr-Mn-W chi phase formed in addition to $M_{23}C_6$. After neutron irradiation, alpha prime and $M_{23}C_6$ formed at 420°C but only $M_{23}C_6$ was present at 600°C. At 520°C, $M_{23}C_6$ was still present, and the matrix consisted of a mixture of ferrite and the Fe-Cr-Mn-W chi phase observed in the aging study. The presence of chi phase in both the thermally aged and neutron irradiated steels indicates that the Fe-Cr-Mn alloy system is prone to intermetallic phase formation so that careful study of the system and the effects of alloying are needed. 11 refs., 4 figs.

8945 (UCID–21821) **IFEL for ECH on CIT, Year-end report, FY89.** Stone, R.; Lee, J.D.; Makowski, M. Lawrence Livermore National Lab., CA (USA). 20 Oct 1989. 15p. Sponsored by U.S. DOE Energy Research. DOE Contract W-7405-ENG-48. Order Number DE90004444. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This report discusses the design considerations for the 280-GHz CIT transport system and shield assessment of 13- and 20-MeV electron beam dumps for a 40-MW IFEL.

8946 Zero-dimensional power balance modeling of FRCs formed in FRX-C/LSM. Chrien, R.E. (Los Alamos National Lab. (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4A1.

Field-Reversed Configuration (FRC) formation without field line tearing and reconnection has been studied in the FRX-C Large Source Modification (LSM) field-reversed theta pinch device (r_c=0.35 m, L=2.01 m). FRCs have been formed over a range of deuterium static fill pressure from 2 mtorr to 10 mtorr. The best results to date have been obtained with fill pressure from 2 to 4 mtorr; FRCs formed with higher fill pressure suffer from rapid internal flux decay. FRC confinement has been examined using a form of the zero-dimensional (O-D) power balance model developed by Rej and Tuszewski. The model has been modified to include convective particle losses of $(5/2)k_BT$ per particle, rather than the rate of $(3/2)k_BT$ per particle that was originally assumed. The results of the experiment are presented and discussed.

8947 Experimentally determined FRC equilibria using visible continuum light. Slough, J.T. (Spectra Technology, Inc., Bellevue, WA (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4A2.

Experimental data combining side-on interferometry and diamagnetic measurements with the reduction of end-on visible continuum light images were used to determine the equilibrium profiles of Field-Reversed Configurations (FRC's) formed on the TRX device. It was found that visible light emitted by the FRC in the wavelength region between 510 nm and 600 nm was free from strong radiation. The plasma emission in this band was further observed to be commensurate with what would be expected from Bremsstrahlung radiation. Due to the n^2 dependence of the continuum light, observation of the axially integrated radial profile of the FRC from the end was not obscured by the plasma exhaust, as is the case with 2-D end-on interferometry. This stronger dependence on density variations and the relative insensitivity to temperature variations, combined with the nearly isothermal temperatures observed for FRC's made the continuum light a sensitive measure of density profile changes. The

axial shape of the FRC appears to become much more racetrack at the large values of chi$_s$. These large s FRC's were predicted to be tilt unstable. Possible explanations are discussed.

8948 A possible experimental stability study of field reversed configurations with neutral beam injection. Tuszewski, M. (Los Alamos National Lab. (US)); Momota, H. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4A5.

So far, field reversed configurations (FRC) with good confinement have only been obtained in a highly kinetic regime, where s (ratio of torus minor radius to average ion gyroradius) is less than about 2. This may be due to formation or stability problems. The authors describe here an experiment which could separate formation and stability issues and begin to provide a solution to the latter. An FRCs – 2 would be formed by the usual field-reversed theta-pinch method, and then translated and trapped with s – 3 in a region where neutral beam injection could take place. One would compare the FRC flux confinement with and without injection since fast ions may increase stability and drive currents, resulting in slower internal flux decay.

8949 Engineering design of the high-power FRC compression heating experiment for FRX-C. Rej, D.J. (Los Alamos National Lab., Los Alamos, NM (US)); Hinckley, J.E. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4A8.

Later this year, the Los Alamos FRX-C/LSM facility will be modified to allow high-power magnetic-compression heating experiments. A compressor, consisting of a single-turn, 3-m-long, 0.47-m-diam coil and a 3.6-m-long, 0.4-m-diam quartz vacuum chamber, will be connected to one end of the θ-pinch. Field-reversed-configuration (FRC) plasmas formed in the θ-pinch will be translated into the compressor. The translated FRCs then will be compressed as the externally-applied B-field is increased in 55 μs from approximately 0.4 to 2.0 T. The principal scientific objectives include the study of FRC energy, particle, and poloidal flux confinement in a high-energy-density regime (eta $\simeq 5 \times 10^{21} m^{-3}$, $T_i \simeq 1$ keV).

8950 2D MHD simulation of the Los Alamos FRC compression experiment. Glasser, A.H. (Los Alamos National Lab., Los Alamos, NM (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4A9.

A 2D MHD simulation study has been made of the planned Los Alamos FRC compression experiment. The experiment consists of three longitudinal sections: a θ-pinch coil source region; a 3-m-long, a 0.5-m-diam. compression region; and a confinement region containing solenoidal and mirror coils. The simulation uses the Brackbill-Milroy 2D MHD fluid code, modified by Hugrass. It divides the cylindrical computational domain into plasma and vacuum regions. In the plasma region, the innermost cylinder, the grid is free to adapt in both directions. The vacuum region is divided into two regions, an outer cylinder in which the radial grid is fixed, and a middle cylinder in which the radial grid is free to adapt. The code solves for plasma density, radial and axial fluid velocities, electron and ion temperatures, and radial and axial magnetic fields. It includes classical, anomalous, and numerical transport coefficients, including Chodura and Lower Hydbrid Drift contributions to the resistivity. The code has been used to simulate a full experimental discharge, including formation, translation, compression, translation, and confinement.

8951 Radiation measurements in a submillimeter wavelength free electron laser. Kirkpatrick, D.A. (Science Applications International, McLean, VA (US)); Freund, H.P.; Bekefi, G.; DiRienzo, A.C.; Ganguly, A.K. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3C4.

Measurements of millimeter and submillimeter wave emission (240-470 GHz) from a free electron laser are reported. Peak output powers of –18 MW are observed at a frequency of 470 GHz, corresponding to an efficiency of –0.8%. The free electron laser operates as a single-pass super-radiant amplifier, where the input signal arises from noise or spontaneous emission of the electron beam. The output frequency is tuned from 270 GHz to 470 GHz by variation of the electron beam energy. Frequency spectra of the output signal are measured using a grating spectrometer, and show linewidths of $\Delta f/f \leq 0.04$. A novel feature of this experiment is the absence of an axial guiding magnetic field, thereby precluding an interaction with the cyclotron maser instability. The gain and spectral characteristics are compared with 3D numerical simulations.

8952 Simulation of plasma erosion opening switches. Mason, R.J. (Applied Theoretical Physics Div., Los Alamos National Lab., Los Alamos, NM (US)); Jones, M.E. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3D5.

The plasma erosion opening switch (PEOS) has been studied with the ANTHEM and ISIS implicit simulation codes. The switch consists of plasma fill injected into a transmission line. The plasma initially shorts out the circuit, but eventually it is removed by self-electrical forces, allowing for the delivery of energy to a load. ANTHEM models the plasma by multiple fluids with electron inertia retained, or by the particle-in-cell (PIC) technique. ISIS is an optimized PIC code. Both codes determine electric and magnetic fields by the implicit moment method. This allows for the study of long time full-switch behavior with simulational zone sizes and time steps that are large compared to a Debye length and plasma period, respectively. Thus, the authors have modeled switch behavior at densities ranging from 5×10^{11} to 5×10^{14} electrons/cm^{-3} over drive pulses ranging from 5 to 250 ns. Here, the magnetic field rose linearly from zero to 0.8 or 3.0 Tesla. Switch gaps spanned from 1.0 to 8.0 cm, and inner radii ranged from 0.5 to 20.0 cm. Opening dynamics is shown to depend sensitively on the assumed electron emission thresholds at the cathode, and on the effective conductivity of the anode. The particle simulations predict broader current channels than the multi-fluid calculations - reasons for this are discussed. The effect of numerical diffusion in implicit simulations is examined. The response to realistic load impedances (10 Ohms for Sandia National Laboratory's PBFA II accelerator) of the opening characteristics is described. Advantages from plasma fill near the load are investigated. The action of preset initial magnetic fields aligned with the power flow, and of trigger magnetic fields for controlled removal of the plasma is discussed.

8953 Design verification of the ignitron-switched energy storage modules for the LSX FRC device. McDonald, K.F. (Spectra Technology, Inc., Bellevue, WA (US)); Mayerchak, M.A.; DeHart, T.E.; Hedeen, P.F.; Kimball, W.S.; Hoffman, A.L. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3A9.

LSX is an FRC theta-pinch device currently under construction. It is designed to employ a modular +-25 kV energy storage system and will be switched by some 380 ignitrons. Each energy storage module will utilize 4 series type D start switches and 4 series type D crowbar switches. In all, 38 such energy storage modules will deliver 1.7 MJ of stored energy to a single turn magnet load at a peak current of 3.4 MA. A design verification test (DVT) has been conducted on a single module of the 38 module energy storage system. The prime focus of this work is to document the feasibility of using ignitron switching. Subjects addressed include coulomb-lifetime data, voltage holdoff, turn-on delay and jitter, and some factors affecting these topics such as triggering, conditioning, and

ignitron thermal control. Both type A and type D switches were tested, using samples from both known sources. In addition, testing was done to confirm the module configuration, busswork, connectors, cabling, components, and characteristic waveforms. This paper presents the data and results of this DVT.

8954 Design and design verification of the plasma vessel for the LSX FRC experiment. Crawford, E.A. (Spectra Technology, Inc., Bellevue, WA (US)); Carey, L.M.; DeHart, T.H.; Harding, D.G.; Hoffman, A.L.; Roberts, W.S.; Slough, J.T.; Steinhauer, L.C. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3A10.

The LSX experiment is a large field reversed theta-pinch device which will produce field reversed configurations (FRC's) by forced reconnection. An insulating vacuum vessel is required for rapid changes in magnetic flux during formation. The large dimensions of the LSX plasma vessel, 0.8m diameter by 6.25m long, present an interesting challenge in materials selection, sealing, design of support systems and procurement of components. The authors use design verification tests (DVTs) in the LSX program to reduce the risk of unsatisfactory performance. In the case of the plasma vessel design, the first DVT, called component tests, included a series of experiments using the old TRX device to identify the best material for the LSX vacuum vessel and verified the concept of using a sectionalized tube to reduce the component size to manageable levels. A sectional quartz plasma vessel was selected as a result of this preliminary DVT. A second DVT, called the plasma tube DVT, is part of the LSX program. They will report details of the plasma vessel design as well as initial results from the plasma vessel DVT. These are expected to include results of evacuation of the test vessel and conclusions concerning the proper choice of materials for the seals. Conclusions concerning the anticipated impurity level in the LSX vacuum system are also presented.

8955 Explosive-generator-powered vacuum-power-flow experiment. Freeman, B.L. (Los Alamos National Lab., Los Alamos, NM (US)); Armstrong, W.; Brownell, J.H.; Davis, H.A.; Rickel, D.G.; Sheppard, M.G.; Stokes, J.L.; Toevs, J.W.; Clark, M.C. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4D7.

The authors have fielded an explosive-generator-powered, vacuum-power-flow experiment. The purpose of this test was to qualify this assembly for future tests that would power live loads for times $\geq$ 1 μs. A 13.2-cm x 52.8-cm, plate generator was energized with an initial current of –1.8 MA and reached a final current of –6.8 MA before burning out after its 14 μs run. The magnetically-insulated transmission line (MIT-Line) was connected to the generator via a detonator-actuated switch (closed at 12 μs) and a 7.5:1 step-up transformer. This MIT-Line had a center conductor with a diameter of 33.6 cm and an outer conductor with an inner diameter of 39.3 cm. A 20-cm-wide band of velvet was placed around and very near the end of the cathode. The purpose of the velvet was to start emission from the end of the cathode and guarantee magnetic insulation along the length of the MIT-Line at the earliest time in the discharge. During this experiment, a maximum voltage of –360 kV was delivered to the MIT-Line with a duration of $\geq$2 μs for the voltage above 100 kV. After the first 1.2 μs, the MIT-Line experienced a streamer instability which disrupted uniform current flow. However, the subsequent discharge was sufficiently pinched that the reflected impedance of the vacuum load remained close to the 2.5 Ω of the early MIT-Line performance.

8956 Extension of the coaxial slow source to slower rise times. Vlases, G.C. (Univ. of Washington, Seattle, WA (US)); Pietrzyk, Z.A.; Smith, R.; Raman, R. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4A6.

The Coaxial Slow Source is a device which produces an annular FRC plasma configuration in the space between two θ-coils with radii 7 and 21 cm, and length 95 cm[1]. Earlier versions of the CSS used effective rise times of 15 and 30 μsec, and produced the desired plasma configuration at loop voltages of 1-2 kev, in contrast to the 100 kev loop voltage typically used in conventional FRC devices. The CSS has recently been modified by the addition of more capacitance on the inner and outer coil circuits to produce an effective rise time of about 60 sec. In addition, active magnetic mirrors have been installed, capable of providing mirror ratios up to two, to control axial motion of the plasma. An upgraded preionization system has also been installed (glow discharge followed by two ringing θ discharges) to extend operation to fill pressures as low as 2 mT. Diagnostic systems in operation include a magnetic probe array and flux loops, a six-channel axial viewing quadrature interferometer, fast photography, and spectroscopy. The completion of a Thomson scattering system is expected by April 1988. Preliminary results with this modified CSS show that the configuration lifetime has been extended to about 90 μsec, or roughly 1.5 times the effective rise time, in agreement with results from the earlier systems.

8957 The Los Alamos deuterium fiber high density Z pinch experiment. Scudder, D.W. (Los Alamos National Lab. (US)); Hammel, J.E.; Shlachter, J.S.; Lovberg, R. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 2P48.

The deuterium fiber high density Z pinch at Los Alamos is a linear Z pinch run as near as possible in radial equilibrium. The plasma is formed from a fiber of solid deuterium ice, and the plasma density is maintained near solid density. Although magnetically confined, the parameters of this plasma are much closer to those encountered in inertial confinement fusion than in toroidal magnetic fusion. The magnetic confining field in present experiments exceeds a megagauss, and in the next generation of experiments beginning this year at Los Alamos (and in similar ones at NRL) they may exceed 100 megagauss. Such a linear Z pinch with purely azimuthal field is predicted by MHD theory to be unstable to m=0 and m=1 modes, with growth rates comparable to the thermal velocity. In contrast to these predictions, experimental results show stability for 100-200 growth times. Maintenance of equilibrium during the heating phase of such a pinch requires that the current follow a prescribed time history. A simple model of the heating process predicts that the current should rise rapidly to a megampere and continue more slowly to the Pease current of about 1.4 MA, where steady state equilibrium is possible. Deficiencies are being addressed by a new experiment at Los Alamos, the Zebra 1.2 MA Fiber A pinch. A new generator operating at 3 MV feeding a vertical water transmission line will provide current rising to 1.2 MA in 100 ns in a 5 cm fiber pinch. The generator design, the experimental arrangement and the initial experiments on the Zebra device are described. Experiments have continued on the 250 kA experiment during construction. A CCD-based shlieren microscope has been developed with a spatial resolution of 4 μm and the ability to make two 150 ps exposures separated by 10 ns. This diagnostic and results are described.

8958 Computer simulations of compact toroid formation and acceleration. Peterkin, R.E. (Mission Research Corp., Albuquerque, NM (US)); Buff, J.; Frese, M.H.; Roderick, N.F.; Clouse, C.J.; Dietz, D.; Hackett, K.E.; Rowley, J.E.; Sovinec, C.R. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3A6.

Experiments to form, accelerate, and focus compact toroid plasmas will be performed on the 9.4 MJ SHIVA STAR fast capacitor bank at the Air Force Weapons Laboratory during the next few years. The MARAUDER (Magnetically Accelerated Rings to Achieve Ultrahigh Directed Energy and Radiation) program is a research effort to accelerate magnetized plasma rings with masses between 0.1 and 1.0 mg to velocities above 10^8 cm/sec and energies above 1 MJ. Research on these high-velocity compact toroids may lead to

development of very fast opening switches, high-power microwave sources, and an alternative path to inertial confinement fusion. Design of a compact toroid accelerator experiment on the SHIVA STAR capacitor bank is underway, and computer simulations with the 2 1/2-dimensional magneto-hydrodynamics code, MACH2, have been performed to guide this endeavor. Preliminary calculations of formation and equilibration of a low beta magnetic force-free configuration (curl B - κ B[have been performed with MACH2. The focusing and acceleration of the toroid has been simulated with the inclusion of resistive diffusion. The authors have found that the resiliency of the accelerated compact toroids against resistive decay is sensitive to the model that is used for the plasma resistivity.

8959 Review of field-reversed configuration stability. Barnes, D.C. (SAIC, Austin, TX (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4A3-4.

A field-reversed configuration (FRC) is an axisymmetric compact torus (CT) plasma confinement geometry with negligible applied toroidal field. Plasma confinement is provided only by a poloidal field generated by diamagnetic plasma currents flowing in the high-β CT. A critical issue in the development of the FRC toward a fusion reactor relevant plasma is maintaining the good macroscopic stability observed in past and present experiments. A review of the theory and observations of the MHD and kinetic stability of the FRC plasma is presented. For a typical, very elongated FRC, equilibrium limits on plasma β and associated trapped magnetic flux are reviewed. The class of possible curvature driven modes is categorized; first for the limit of very large toroidal mode number eta, then for finite eta. Positional stability against rigid shift modes is shown to be easily obtained. Rotationally driven modes are also examined and the stabilizing effect of added multipole fields is described both theoretically and experimentally. Both spectral and initial value linear and nonlinear calculations have been carried out. The state of this body of theoretical analyses of the internal tilt, its comparison with observations, and predictions for future stability limits is reviewed and summarized.

8960 In-situ measurement of currents in magnetized plasmas: Closure, spreading, propagation speeds. . Urrutia, J.M. (Univ. of California, Physics Dept., Los Angeles, CA (US)); Stenzel, R.L. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 1P6.

Time and three-dimensional space resolved measurements of magnetic field perturbations have been performed in a large magnetized discharge plasma ($n_e < 10^{12}$ cm^{-3}, $kT_e <$ S eV, $B_o < 50$ G, dimensions 1 m 1 B_o, 2.5 m parallel B_o). With the help of digital data acquisition system the current density J = del x B/μ_o has been calculated everywhere in space and time. With this powerful diagnostic tool the current flow between positive and negative electrodes located on different magnetic field lines has been investigated. From the propagation speed one can conclude that except in sheaths the current is always carried by electrons. Extraction of ions is balanced by outflow of electrons which, in dense plasmas ($\omega_{pe} >> \omega_{ce}$) can readily occur across B_o in spite of low classical electron cross-field conductivities. Injection of fast electrons from a beam source sets up a current system strongly coupled to the plasma background electrons. Convergence of electrons drifting into a positive electrode creates intense current-driven instabilities which can disrupt the current system and prevent the formation of steady-state currents. Induced currents requiring no electrodes are also investigated. The transition from the single particle regime ($\omega_{rho} << \omega_c$) to the space-charge dominated regime ($\omega_{rho} >> \omega_c$) is explored.

8961 A comparison of electron beam and heavy ion excitation of rare gas-halogen gas mixture. Moratz, T.J. (Univ. of Illinois, Champaign, IL (US)); Kushner, M.J. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4B8.

Rare gas-halogen lasers (eg., XeF, KrF) are commonly excited by electron beams having incident energies of 300 keV - 1 meV. New methods of pumping these lasers use heavy ion beams, either directly, or in the form of energetic fission fragments, having energies of 0.5 - 2.0 MeV/amu. Power deposition proceeds by momentum transfer between the projectile (beam electrons or heavy ions) with an orbital electron. Due to the mass difference of the projectiles of the two excitation methods, the kinetics of the power deposition also differ. In this paper, first principles models for the slowing of electron beams and heavy ions in gas mixtures of interest to the excitation of excimer lasers are presented. The authors compare the secondary electron spectra, W values (energy/ion pair), and the performance of an XeF laser excited by each method. Due to the more favorable mass ratio for e-beam excitation, the secondary electron spectrum is more energetic than with heavy ion excitation. As a result, the efficiency of ionization is higher and the W value for e-beam excitation is lower. The fraction of ionization caused directly by the beam projectiles is larger with heavy ion excitation, as the ions slow in increments of energy not significantly greater than the ionization potential. These differences in excitation methods, though, do not significantly affect the efficiency of excitation of excimer lasers due to the efficiency with with deposited energy flows to the upper laser level, through either the neutral or ion channels.

8962 Generation of high voltages in plasma flow switch experiments at ten megamperes. Alme, M.L. (R and D Associates, Inc., Alexandria, VA (US)); Bird, G.; Boyer, C.; Coffey, S.K.; Conte, D.; Davis, J.F.; Seiler, S.W.; Turchi, P.J.; Baker, W.L.; Degnan, J.H. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3D1-2.

The Plasma Flow Switch utilizes the dynamics of a plasma discharge in vacuum to accumulate magnetic energy in several microseconds and then release this energy to a load region of a new hundred nanoseconds. Experiments have previously been performed using the plasma flow switch on the Shiva Star capacitor bank to drive imploding plasma loads at multimegajoule, multimegampere levels. Recently, experiments have been conducted in which a portion of the switch plasma is used as the current carrying load. These experiments employed the Shiva Star capacitor bank, charged initially to 84 kV (4.6 MJ) to achieve currents in excess of 10 megamperes at the switch region. Comparisons of voltage measurements in the bank transmission line with numerical simulations (MACH2 computer code) indicate that the low density, very high speed flow in the switch supports voltages in excess of 0.5 megavolts at the coaxial gun muzzle. Measurements of hard X-radiation (> 10-100 keV) imply the existence of high energy electrons and are consistent with the generation of high voltages in the plasma flow switch. The relationship of the high voltage pulse and hard X-ray output to the dynamics of the magnetized plasma flow will be discussed.

8963 Disruption and edge current. Murray, J.G. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 2A2.

Disruption is proposed by the author to be a large edge cross current. This paper provides a explanation on how a disruption occurs, the reason for the variations in the severity of the disruption, the justification for the fast decay of energy, the similarities between a disruption and a sawtooth crash, the lack of a consistent precursor or indicator that a disruption is about to take place, a discussion on why the large negative-voltage spike occurs, and most importantly, methods of preventing a disruption or limiting its damage to a tolerable value. Based on the edge-current understanding for disruptions it is proposed that disruptions can be easily eliminated or their damage reduced to negligible values. It is also proposed that the elimination of the edge current and the associated cross current

in the structures will result in many other improvements in tokamak operations, including a much improved confinement time.

8964 Electric fields in decaying CTX spheromaks in the 0.67 m radius mesh flux conserver. Fernandez, J.C. (Los Alamos National Lab. (US)); Jarboe, T.R.; Barnes, C.W. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3A1.

The effective electric field parallel to the magnetic field at the edge of decaying spheromaks has been deduced from equilibrium measurements. It is found to depend on the plasma electron density but not on the electron temperature, consistently with hydrogen ionization dominating the spheromak helicity dissipation. Although not directly measured, the plasma resistivity is expected to be much higher at the edge than at the magnetic axis, an assumption supported by the peaking of the spheromak currents towards the magnetic axis throughout the decay phase. To estimate the electric field, we assume the plasma resistivity to be appreciable only at the open magnetic flux surfaces at the spheromak edge. A floating Langmuir probe has been inserted into the spheromak plasma to qualitatively diagnose the spheromak radial electric fields. The results of these measurements are presented.

8965 Evolution of a z-pinch with constant DI/DT. Robson, A.E. (Plasma Physics Div., Naval Research Lab., Washington, DC (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 2P47.

The evolution of a linear z-pinch in which the current is rising at a constant rate is analyzed in terms of a quasi-static pinch model. It is shown that there is a maximum current in hydrogen or deuterium equal to approximately $\sqrt{3}$ times the Pease-Braginskii current which cannot be exceeded because of radioactive collapse. Higher currents may be obtained in D-T because the pressure of the α particles prevents collapse until all the fusion fuel is consumed, at which point the pinch collapses like a star. The consequences for the pinch as a fusion system are discussed.

8966 Test of a PBFA-II plasma opening switch (POS) on Blackjack 5. Renk, T.J. (Sandia National Labs., Albuquerque, NM (US)); Rochav, G.E.; Mendel, C.W.; McDaniel, D.H.; Moore, W.B.S.; Zagar, D.M.; Mowrer, G.R.; Simpson, W.W.; Bouchier, F.A.; Laderach, G.E. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract AC04-76DP00789. (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 3D3.

High voltage operation (> 20 MV) of the 100 TW Particle Beam Fusion Accelerator-II (PBFA) at Sandia National Laboratories requires the use of a POS with inductive storage for voltage multiplication. The objective of this test series on Blackjack 5 was to further optimize the POS for use on PBFA-II. PBFA-II POS hardware was used for the opening switch in Blackjack 5, yielding an inductance upstream of the POS of 30 nH, with an additional 20 nH being located between the switch and load. Several configuration changes were made during the run, and are discussed. A primary goal was to test for improvements in both azimuthal power flow symmetry and current rise time out of the POS resulting from the use of an improved flashboard plasma source. In addition, the authors looked for repeatability both in the flux output of any given flashboard, and in the amount of total current conducted by the POS. Data for the configurations is presented.

8967 Fundamental studies to reduce high heat flux erosion of surfaces. Gilligan, J. (North Carolina State Univ., Raleigh, NC (US)); Bourham, M.; Auciello, O.; Hankins, O.; Wehring, B. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5C1-2.

Conductor and insulator materials of electromagnetic (EM) launchers are subjected to intense heat fluxes from the passing armature. The authors report on theoretical modeling and experimental verification of the ablation and melting processes occurring in the near surface region. Vapor shielding is said to occur when the ablated surface material absorbs incoming radiation and reduces the total energy transported to the ablating surface. The strong magnetic field present in launchers will also affect the energy transport in the vapor shield by reducing crossfield thermal conduction and possibly increasing the radiation energy density. A plasma ablation gun device, SIRENS, has been built to simulate EM launcher heat fluxes and to explore the effect of large (> 10 T) magnetic fields on the erosion of various material samples. For the transport modeling of the ablated vapor, they employ a 1-D, time-dependent, Lagrangian MHD code, MAGFIRE, which incorporates multi-frequency radiation transport. Many materials have been analyzed. When strong parallel magnetic field effects are included, both the temperature and density profiles are steepened and thermal conduction is reduced.

8968 Fast capillary discharges as a soft x-ray and XUV laser media. Rocca, J.J. (Electrical Engineering Dept., Colorado State Univ., Fort Collins, CO (US)); Marconi, M.C.; Beethe, D.; Villagran, M. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5A6.

Recently soft X-ray laser have been demonstrated using dense plasmas created by high energy lasers as the gain medium. Here the authors discuss the possibility of creating soft X-ray and XUV lasers in recombining plasmas with large length to diameter ratio (1/d>100) created by a fast capillary discharge with relatively low energy. The capillary geometry proposed has advantages that relate to the requirements for the generation of a dense highly ionized plasma as well as its subsequent rapid cooling. Both these conditions are necessary to achieve the large recombination rates associated with the gains required for laser action in the extreme ultraviolet spectral region, where optical resonators are not yet available. In addition the capillary limits the plasma radius, helping to avoid self-absorption of the lower laser level radiation. The capillary geometry provides a small plasma volume and an adequate resistance for ohmic heating. A more significant characteristic of the capillary plasmas is the rapid cooling rate due to high heat electron conduction from the plasma volume to the capillary walls. In hot plasmas of such a geometry, conduction cooling can be significantly greater than radiation cooling, as shown by the results of a time dependent collisional-radiative plasma model. XUV gain calculations in other ions are also discussed.

8969 Charge conservation in electromagnetic particle-in-cell simulations. Nielsen, D. (Lawrence Livermore National Lab. (US)); Drobot, A. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5D5.

A number of algorithms have been developed to avoid instabilities caused by the natural discrepancy between the charge conservation equation implied by electromagnetic field solvers and the actual charge determined from the particle distribution. One strategy has been to correct the electric fields found from the electromagnetic field advance by imposing a Poisson correction. This approach, while exact, is difficult to implement in simulations with complicated geometries and can result in a significant increase in the computational time required for large problems. An alternate method is to use a formulation for the current density source terms which yields exact conservation. This approach again leads to a significant increase in the computational time, scaling in proportion to the number of particles in the simulation. A recent algorithm proposed by Marder suggests an elegant approximate method for enforcing charge conservation. The authors present an analysis of the method and a generalization.

8970 Mode and phase locking of a cavity vircator by injected microwave power from a relativistic magnetron. Price, D.

(Physics International Co., San Leandro, CA (US)); Sze, H.; Woo, W.; Fittinghoff, D.; Benford, J. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5B7.

The authors report results of experimental research which demonstrates the influence of externally injected microwave power on the behavior of a cavity vircator oscillator. The injected signal is provided by a relativistic magnetron. The virtual cathode oscillator can be primed to start at the magnetron frequency if the injected signal prefills the vircator cavity, or the vircator frequency can be pulled to the magnetron frequency if the injected signal arrives in the cavity after the vircator starts emitting. In either case the vircator is rapidly frequency locked to the injected signal. They are exploring a high injected power regime, the ratio of the oscillating vircator and the driving magnetron electric field amplitude (in the cavity) is nearly unity. Recently, the authors demonstrated that resonant cavities which enclose the virtual cathode reduce the vircator bandwidth and enhance its efficiency. They successfully demonstrated the phase-locking of two identical well-coupled, high power magnetrons. By combining the expertise gained from these two experiments they demonstrate the feasibility of phase control of an array of high power oscillators by connection to a single driving master oscillator. Time resolved measurements of the frequency and phase difference between the two microwave sources are presented and compared to theory. Details of both the injected and radiated microwave pulses and intracacies of the tuning procedures are discussed.

8971 **Electromagnetic computer simulations of collective ion acceleration by a relativistic electron beam.** Galvez, M. (Earth and Space Science, Los Alamos National Lab., Los Alamos, NM (US)); Gisler, G.R. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P2.

A 2.5 electromagnetic particle-in-cell computer code is used to study the collective ion acceleration when a relativistic electron beam is injected into a drift tube partially filled with cold neutral plasma. The simulations of this system reveals that the ions are subject to electrostatic acceleration by an electrostatic potential that forms behind the head of the beam. This electrostatic potential develops soon after the beam is injected into the drift tube, drifts with the beam, and eventually settles to a fixed position. At later times, this electrostatic potential becomes a virtual cathode. When the permanent position of the electrostatic potential is at the edge of the plasma or further up, then ions are accelerated forward and a unidirectional ion flow is obtained otherwise a bidirectional ion flow occurs. The ions that achieve higher energy are those which drift with the negative potential. When the plasma density is varied, the simulations show that optimum acceleration occurs when the density ratio between the beam (n_b) and the plasma (n_o) is unity. Simulations were carried out by changing the ion mass. The results of these simulations corroborate the hypothesis that the ion acceleration mechanism is purely electrostatic, so that the ion acceleration depends inversely on the charge particle mass. The simulations also show that the ion maximum energy increased logarithmically with the electron beam energy and proportional with the beam current.

8972 **Simulations in 3D of heavy ion fusion beam compression with quadrupole focusing.** Mark, J.W.K. (Lawrence Livermore National Lab., Livermore, CA (US)); Brandon, S.T.; Nielsen, D.; Chang, C.L.; Drobot, A.T.; Mankofsky, A. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract W-7405-ENG-48. (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P1.

Longitudinal beam compression is essential to produce the requisite peak power for driving ICF targets; it could also produce the proper pulse-shapes. Realistic effects of quadrupole focusing and displaced beam centroid in the presence of space charge are being studied with the help of the 3D ARGUS particle-in-cell code. The authors discuss the results of these studies.

8973 **Plasma channels for the propagation of intense light ion beams.** Peterson, R.R. (Fusion Technology Institute, Univ. of Wisconsin-Madison, Madison, WI (US)); Moses, G.A. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6B5.

Beam propagation in preformed plasma channels is a possible method for providing the required stand-off distance between the ion diodes and the targets in Inertial Confinement Fusion (ICF) facilities. The stand-off distance is required for the protection of the diode from the blast of the target explosion. The stand-off distance also allows the time-of-flight bunching and pulse shaping that is required for successful implosion of ICF targets. In the plasma channel concept, large electrical discharges, guided by laser preionization, would rarify the channel and form ion confining azimuthal magnetic fields. Important issues to the channel concept are the behavior of the channel during formation, the ion transport efficiency, and the behavior of channels in the presence of intense ion beams. The issues of ion transport efficiency and channel stability are discussed. The authors concentrate on the issue of channel formation in this presentation. They used a Lagrangian magnetohydrodynamics computer code with multigroup radiation diffusion to study the radial behavior of channels during formation. They studied the formation of channels in different gases, with different discharge current histories, and with different laser profiles. They believe that the key to forming the plasma channels that are required for ICF is in keeping the gas temperature low except in the region very near the axis of the channel. From the parameter studies mentioned above, they found that by controlling the radiant heat transfer we can form the best channels. They show calculations for channels formed in hydrogen and nitrogen gases.

8974 **Status report on the Star Fire railgun development project.** Hawke, R.S. (Lawrence Livermore National Lab., Livermore, CA (US)); Asay, J.R. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). DOE Contract W-7405-ENG-48. (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5C4.

The Star Fire Project is a joint SNLA/LLNL effort to develop a combined two-stage light-gas gun (2SLGG) and railgun into a three-stage hypervelocity launcher for equation-of-state (EOS) research. The 2SLGG is used to accelerate a projectile to a velocity of 6-9 km/s. The railgun serves as the third stage to further accelerate the projectile. The high injection velocity will minimize barrel ablation and armature contamination. Hydrogen is used as the injection gas and serves to reduce the probability of forming secondary arcs. VISAR is used for continuous precision projectile velocity measurement. This paper discusses the results of armature formation tests, the use of the railgun stage to increase projectile velocity, and armature diagnostic measurements.

8975 **The implicit ANTHEM code for pulsed power modeling.** Mason, R.J. (Applied Theoretical Physics Div., Los Alamos National Lab., Los Alamos, NM (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6P48.

The implicit plasma simulation code ANTHEM was originally constructed for application to transport problems in inertial confinement fusion. The code calculates 2D electromagnetic fields by the implicit moment method. The plasma is advanced as either multi-fluid components with inertia retained, or as particles-in-cell. Classical and/or anomalous scattering of electrons is available as an option. Recently, ANTHEM has been significantly enhanced for application to the pulsed power modeling of: plasma erosion opening switches, field penetration and ion transport in plasma channels, and current initiation in high density Z pinches. Enhancements include options

for externally applied time dependent magnetic fields, absorbing and/or emitting conducting boundaries, internal dense plasma boundary regions, relativistic fluid and/or particle electrons, and cylindrical geometry. Details of these additions are described. Comparisons of multifluid and particle calculations is presented in typical applications.

8976 Numerical simulation of collective ion acceleration in a localized plasma source-vacuum system. Yao, R.L. (Univ. of Maryland, College Park, MD (US)); Striffler, C.D. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6P52.

In experiments in which an intense relativistic electron beam was injected into an evacuated drift tube with a gas cloud located near the injection plane, ions with energies of up to several hundred MeV were produced when the injected electron-beam current exceeded the space-charge limiting current. In order to understand and to optimize ion acceleration in these experiments, the authors have developed the ID electrostatic PIC code NEWTON. Simulations performed with this code give the following general picture for the acceleration process. Soon after the electron beam is injected into the drift tube, a virtual cathode forms near the injection plane. Ionization of the neutral gas causes the virtual cathode to move downstream to the end of the gas cloud. During this movement of the virtual cathode, ions produced by ionization of the neutral gas are accelerated to energies several times the injected electron-beam energy. They present a more detailed picture of the acceleration process. They report the observed dependence of the peak energy and the number of collectively accelerated ions on the electron-beam current, the electron-beam voltage, the neutral-gas pressure, and the neutral gas pressure profile.

8977 Fast marx driver for inductive store - opening switch electron beam generator. Sincerny, P. (Physics International Co., San Leandro, CA (US)); Levine, J.; Goyer, J.R.; Krishnan, M.; Pearce, K.; Barreto, G.; Douglas, J. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P27.

A fast Marx (320 κJ, 500 etaH, 810 κV) has been developed as a driver for an electron beam generator. This generator uses an inductive store with an opening switch to compress and amplify the power pulse. The 320 κJ Marx consists of four parallel 80 κJ Marxes to minimize the inductance. The 320 κJ Marx has been used to develop vacuum opening switches. These switches have demonstrated up to 22% efficiency and pulse compression of 5 to 1. Two switch concepts have been successfully tested as electron beam diodes on this Marx bank. The energy delivered to diode, the output voltage and power produced by this new high power generator will be presented. This generator serves as the proof-of-principles demonstration of inductive store/opening switch technology as an alternative to conventional capacitive storage technology.

8978 A particle simulation of the tearing mode instability at the dayside magnetopause. Allen, C.W. (Geophysical Institute and Dept. of Physics, Univ. of Alaska, Fairbanks (US)); Swift, D.W. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 4P47.

The authors used a two and one-half dimensional electromagnetic particle code to investigate the collisionless tearing mode under conditions characteristic of the dayside magnetopause. The initial configuration is a tangential discontinuity separating a magnetosheath plasma with a beta of three and a vacuum on the magnetosphere side. The plasma consists of electrostatically coupled ions and electrons. The initial magnetic field consists of a shearing component which reverses sign through the current sheet, and a constant B_y. By changing the asymptotic values of the magnetic field and magnetosheath number density they can start the simulation with a chosen amount of total field rotation across the magnetopause while keeping the magnetosheath plasma beta constant. For a magnetosheath beta of three they found that the growth rate of the most unstable mode decreases as $Sin^2(\theta/2)$ where θ is the angle between the magnetic field vectors on either side of the discontinuity. The wavelength of this fastest growing mode increases as θ is reduced. The total magnetic flux trapped in the fully developed magnetic island is proportional to $Sin^4(\theta/2)$. The authors' linear growth rate calculations support these results. These and the results of the simulation are used to predict tearing mode behavior.

8979 Numerical simulation of the PBFA-II plasma opening switch. Steen, P. (S-Cubed, A Div. of Maxwell Labs., Inc. (US)); Wilson, A. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P22.

The 2-D fully electromagnetic (Rθ) particle code FRED is utilized to simulate the bi-conic geometry POS on PBFA-II. A double-ionized carbon plasma with a density $N = 4 \times 10^{12}$ cm^{-3} and velocity $\nu_{rho} = 10$ cm/μs is injected from the anode using a unique algorithm which maintains good ion particle statistics during the the POS opening phase. Space-charged limited emission from the cathode is assumed to require a nominal 0.3 MV/cm threshold. Regions of the switch far away from the POS are simulated with lumped circuit elements whose voltages and currents are self-consistently coupled to the electromagnetic mesh assuming 1-D TEM field distributions at the mesh boundaries. A fixed load impedance of 10 ohms is imposed downstream of the POS and a realistic open circuit voltage is applied upstream. Careful tailoring of the FRED code to exploit the architecture of the CRAY 1 permitted the simulation to be carried out with the real electron-ion mass ratio and the actual pulse timescales (on the order of 100 ns). Results are found to resemble earlier simulations of Blackjack 5 performed in cylindrical geometry.

8980 C-X neutral spectra from ZT-40M. Munson, C. (Los Alamos National Lab. (US)); Carolan, P.G.; Bunting, C.A. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P14.

A series of experiments have recently been completed on the ZT-40M Reversed Field Pinch at Los Alamos for which Neutral Charge Exchange (C-X) spectra have been measured using both the previously reported Time-of-Flight (TOF) system, and a 5 channel electrostatic Neutral Particle Analyzer (NPA). The experiments involved measurements of ion and electron temperatures for a variety of discharge conditions including scans of flat-top current levels, different values of the toroidal field reversal parameter ($F = B_{phi}(a)/\langle B_{phi} \rangle$), ramped current discharges, discharges with a movable graphite paddle limiter inserted into the edge of the plasma from above, and discharges with Deuterium pellet injection. Both the TOF and NPA systems view the plasma along chords from the outside midplane, and are separated by 60^0 toroidally. Core ion temperatures are obtained by examining the asymptotic tail of the neutral particle efflux spectrum. Detailed comparisons of the neutral particle spectra obtained with these two systems for the various operating conditions will be presented.

8981 Numerical studies of toroidicity simulation in a linear heliac. Nelson, B.A. (Univ. of Washington, Seattle (US)); Ribe, F.L.; Spanjers, G.; Barnes, D.C. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651--: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6P49.

The High Beta Q Machine (HBQM) is a three-meter theta-pinch that can be configured with an iota = 1 compression coil set and an axial hardcore center conductor to form linear high beta heliac plasmas. A critical issue in a toroidal heliac is the predicted degradation of magnetic flux surfaces by magnetic island formation owing to the loss of helical symmetry. Finite plasma pressure can drive currents in these magnetic islands and degrade confinement. Approximate

analytical expressions for the first order corrections to the vacuum linear heliac magnetic fields have been derived for two cases: large aspect ratio toroidicity and a radial translation (shift) of the hardcore conductor. A magnetic field line following code, HELIK, shows the similarity of field line puncture plots for the toroidal, and shifted hardcore cases. These expansions are also found to possess similar Roozer harmonic spectra of the magnetic flux coordinate system Jacobian ($1/B^2$). This similarity is so great that toroidal effects can be coupled with a shifted hardcore in such a way as to heal the magnetic flux surfaces, partially restoring the situation of helical symmetry.

8982 **The Reversatron II RFP.** Greene, P. (Univ. of Colorado-Boulder (US)); Robertson, S. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P13.

The Reversatron II RFP is a new version of the Reversatron RFP with new field coils, vacuum chamber, and removable shell. The OH coils generate negligible field (≈ 10G) at the plasma so that the OH coil current does not affect equilibrium. The VF coils are inductively decoupled from both the plasma and the OH circuits to simplify equilibrium control. The OH coils which are near to the plasma have coaxial feeds to minimize field perturbations. The measured nonuniformity of the applied fields is at the 10 Gauss level (peak-to-peak). The vacuum chamber resistance is 40 mΩ to reduce the chamber current and the pumping port (7.5 cm W x 12 cm H) is bridged by two conductors to reduce field errors due to interruption of the chamber current. The 144 turn toroidal coil is uniformly spaced except at the pumping port where four turns are skewred. The shell is of 0.1 mm brass (≈ 0.1 msec penetration time) and has one poloidal and two toroidal gaps. Initial operation with no shell has produced RFP discharges lasting 0.4 msec with 23 kA plasma current in 15 mTorr He. Magnetic probes sensitive to m = 1 modes show fluctuations similar to those seen in Reversatron I with no shell. Preprogramming of the vertical field waveform by varying circuit elements appears to provide adequate equilibrium control. Experiments are planned in which the vertical field index will be varied.

8983 **Ion beam fusion targets which utilize direct drive efficiency while optimizing symmetry as well as those which utilize polarized DT-fuel.** Mark, J.W.K. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6B8-9.

The authors have investigated several examples of ion beam targets which utilize the energy efficiency of direct drive while at the same time optimizing on the symmetry requirements. Heavy ion beams of charge state $Z \geq 3$ at 5-10 GeV have ≤15-20 m bending radii with 3.5 Tesla fields. Beams like them could be used with targets involving direct drive. Control of asymmetries in direct-drive ion beam targets depends on control of the effects of residual target asymmetries after an appropriate illumination scheme has been adopted. In this article, they outline results on their investigations into ion beam target concepts in which the effects of residual asymmetries are ameliorated. The beams are placed according to their axially symmetric Gaussian-quadrature illumination scheme. The targets survive the effects of residual asymmetries in their recent 2D hydrodynamic simulations. The authors also discuss other ion beam targets, including those utilizing the additional positive effects of polarized DT-fuel.

8984 **Numerical simulation of intense beam propagation and plasmoid formation in a localized plasma source-vacuum system.** Yao, R.L. (Univ. of Maryland, College Park, MD (US)); Guillory, J.; Striffler, C.D. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P8.

In experiments in which an intense relativistic electron beam was injected into an evacuated drift tube, a dramatic increase in the amount of current which propagated to the the end of the drift tube was observed when gas was puffed into the drift tube from a nozzle located near the injection plane. The authors report results of numerical simulations performed with the code NEWTON which was developed to model the experiments. Newton is a 1D electrostatic PIC code which models ionization of the neutral gas by beam electrons and plasma ions and plasma electrons produced by ionization of the neutral gas. The code shows that the increase in propagated current results from the formation of a dense quasi-neutral beam composed of beam electrons and plasma ions which are accelerated downstream by the electron-beam space-charge fields. They present a detailed picture of the formation and a propagation of this beam as depicted by NEWTON. They also present the observed dependence of various properties of the quasi-neutral beam as a function of electron-beam injection energy, electron-beam injection current, neutral gas pressure, and neutral-gas pressure profile.

8985 **Energy confinement in a wall-confined spheromak plasma.** Craddock, G. (SAIC, Austin, TX (US)); Barnes, D.C.; Nystrom, D.; Bourianoff, G.; McBride, J. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P19.

The MIIF concept is to use impact techniques to produce a quasi-spherical compression of magnetized wall-confined plasma ($\beta >> 1$), yielding thermonuclear conditions with impact velocities of a few 10 km/s. Scalings of the energy confinement time are estimated for this wall-confined spheromak plasma. Numerical and analytic results are presented for the ion thermal transport dominated interior, where the magnetic field is found to decrease thermal transport. Analytic estimates indicate that anomalous (turbulent) transport effects are important in the colder edge, near the wall, where resistive interchange modes, rippling modes, and drift waves dominate classical ion transport. The MIIF plasma would thus lose energy quickly in the edge, leaving behind a longer confined hot core.

8986 **Arc motion in railgun plasma armatures.** Keefer, D. (Center for Laser Applications, Univ. of Tennessee Space Institute, Tullahoma, TN (US)). pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5C3.

Recent in-bore optical measurements in the 1 cm square bore UTSI railgun have revealed that a dark, non-emitting and presumably cold buffer region can separate the driving arc from the projectile by as much as 5 bore widths. This is consistent with the common observation that the back sides of railgun projectiles suffer no ablation damage from the arc, even when substantial ablation from the rails and insulator surfaces is observed. This dark zone is not predicted by current time dependent or steady-state theoretical models. There is some experimental evidence that the zone may be formed, initially, during the fusing transient, but reexamination of a theory due to Maecker suggests that there are physical mechanisms that can cause the arc to move away from the projectile even in a quasi-steady-state. Maecker's general theory for arc motion and displacement has been applied to the pressure dependent plasmas and geometry appropriate for railgun arcs, and it was found that the motion of the arc relative to the material in which it is imbedded is controlled by the relative magnitude of inhomogeneous absorption from the electromagnetic field and the diffusion of energy through radiation and thermal conduction. The pressure dependence of the thermodynamic and transport properties determine the relative importance of these two mechanisms, and these have been evaluated for copper plasmas under conditions typical of their experiments.

8987 **High performance fuse opening switches for magnetic flux compression generator applications: Theory and computation.** . Lindemuth, I.R. (Los Alamos National Lab., Los Alamos, NM (US)); Reinovsky, R.E.; Hodgdon, M.L.; Vorthman, J.E. pp. 166 of Conference record of the 1988 IEEE international conference on

plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 5P30.

Experiments have been conducted in which aluminum and copper foil fuses have been driven at 300-800 κA currents for 50-100 μs with capacitor banks and high-explosive driven magnetic flux compression generators (FCG). Concurrent with the experimental effort is a theoretical and computational effort to predict the experimental observations from more-or-less first principles. A close correlation between computations and actual experiments has enabled model adjustments which are then used to design new experiments. A simplified analysis based on early work and extended by the authors to examine switching under an assumption of a linearly rising resistance shows that appropriate fuse parameters and the resulting fuse performance can be estimated. The authors developed a computer code which computes the fuel resistance multiplication M from first principles. The computer model has demonstrated that M is determined by the fuse equation-of-state properties, the fuse electrical resistivity function, the way in which the cross-sectional area is proportioned between width and thickness, the amount of tamping, the rate at which the circuit can deliver energy to the fuse as it bursts, and other parameters. With appropriate adjustment, the model is in agreement with the experimental observations. Implications for the use of fuses as current interrupters in large (10-MJ class) systems are discussed.

8988 **Multimegawatt disk generator system for space applications.** Solbes, H. (TRW Inc. (US)); Iwata, H. pp. 160 of Conference record of the 1988 IEEE international conference on plasma science (abstracts). IEEE Service Center, Piscataway, NJ (1988). (CONF-880651–: IEEE international conference on plasma science, Seattle, WA (USA), 6-8 Jun 1988).

Technical Paper 6A4.

The conceptual design of a 100 megawatt - 500 seconds disk MHD generator system suitable as a burst power source for a space based neutral particle beam (NPB) is presented. The system features two disk generators operated in the magnetic field produced by a single circular superconducting magnet. Gelled reactants are used as the energy source. The oxidizer gel includes the alkali seed. The high heat flux areas of the power train are water cooled. Heat is rejected to a hydrogen stream which is also used for cooling of the exit section. The hydrogen is also used to mitigate the effects of the exhaust products of combustion on the platform. The two disk channels are operated in parallel. A dc to dc converter consolidates the channel's output into a single 100 kilovolt dc output. Critical development issues relevant to the development of such power systems are identified and discussed. A R and D plan aimed at establishing the technical feasibility of the proposed system is also presented.

8989 **Magnetic and inertial fusion status and development plans.** Storm, E. (Inertial Confinement Fusion Program, Lawrence Livermore National Lab., Livermore, CA (US)). vp of The 8th Miami international conference on alternative energy sources. Volume 1-2 (Condensed Papers). Vezioglu, T.N. Clean Energy Research Inst. University of Miami, Coral Gables, FL (1988). DOE Contract W-7405-ENG-48. (CONF-871204–: 8. Miami international conference on alternative energy sources, Miami Beach, FL (USA), 14-16 Dec 1987).

Fusion, pursued by both magnetic and inertial research programs, continues to be a strong candidate for providing a long-term energy source which is intrinsically safe and inexhaustible. The status of magnetic and inertial fusion is described in terms of accomplishments within the research programs of each concept. The improvement in plasma parameters (most frequently discussed in terms of the etatauT product of density, eta, confinement time, tau, and ion temperature, T, can be linked with the construction and operation of experimental facilities. The scientific progress exhibited by larger-scale fusion experiments within the U.S., such as TFTR for magnetic studies and Nova for inertial studies, has been optimized by the theoretical advances in plasma and computational physics. Both TFTR and Nova have exhibited ion temperatures in excess of 10 keV (100,000,000^{0}C) at confinement parameters of etatau near 10^{13}cm^{-3} sec. At slightly lower temperatures near a few keV, the value of etatau exceeded 10^{14}cm^{-3} sec. in both devices.

8990 **The compact ignition tokamak (CIT) and the international thermonuclear experimental reactor (ITER): An overview.** . Uckan, N.A. (Oak Ridge National Lab., Oak Ridge, TN (US)). vp of The 8th Miami international conference on alternative energy sources. Volume 1-2 (Condensed Papers). Vezioglu, T.N. Clean Energy Research Inst. University of Miami, Coral Gables, FL (1988). DOE Contract AC05-84OR21400. (CONF-871204–: 8. Miami international conference on alternative energy sources, Miami Beach, FL (USA), 14-16 Dec 1987).

The Compact Ignition Tokamak (CIT) program has the mission of realizing, studying, and optimizing ignited plasma operation. The program is managed by the Princeton Plasma Physics Laboratory. A national design team, with representatives from essentially all of the major U.S. fusion laboratories, universities, and industries, has developed the conceptual design for the CIT. The device is compact (with a major radius of ~1.6-1.8 m and a plasma minor radius of ~0.5-0.6 m) and uses copper coils to produce about a 10-tesla toroidal magnetic field and about a 10-megamperes plasma current in a dee-shaped plasma cross section. It is capable of both divertor and limiter operation and has sufficient access to accommodate significant auxiliary heating to enter the ignited plasma regime. The CIT has a unique capability for providing an essential bridge between the present-day tokamak experiments and future fusion experiments (e.g., ITER) and power reactors. Major design features and expected plasma performance characteristics are discussed. At present, four candidate design options for the ITER are being developed. Major design features and expected operating characteristics of each design are discussed.

8991 **Configuration development and remote maintenance considerations for the TIBER neutral beam system.** O'Toole, J.A. (Grumman Space Systems, Bethpage, NY (USA)); Brook, J.W.; Luzzi, T.E.; Sedgley, D.W. vp of Proceedings of the 12th symposium on fusion engineering. IEEE Service Center, Piscataway, NJ (1987). (CONF-871007–: 12. symposium on fusion engineering, Monterey, CA (USA), 12-16 Oct 1987).

TIBER features a beam driven current tokamak designed for CW operation. The Neutral Beam system design was developed using a set of negative ion technology-based sources and gas neutralization to provide the required 50 MW to the device. It features two 40 m long beamlines, each having two 9 m high source arrays; each is composed of 10 individual sources spaced so that if any were to fail to ground potential, the others would not be affected. Cryopumping is used to provide the required high vacuum. The sources, gas neutralizer, and 4 m of drift space are magnetically shielded. The magnetic field of the tokamak is used to divert that portion of the beam which is not neutralized. These particles are intercepted by dumps arrayed along the drift duct. An array of water-cooled swirl tubes intercepts that portion of the beam that does not pass through the dedicated port. The TIBER maintenance philosophy is that all maintenance within the reactor vault will be accomplished using remote maintenance techniques. The Neutral Beam system is configured so its components can be accessed and maintained using remote maintenance technology. A modular approach providing for replacement of failed components is followed. Lifetime components are also designed using the modular approach. A configuration enhancing remote maintenance for the TIBER Neutral Beam system and a unique approach to ion source maintenance is discussed.

8992 **RF transmission and matching for TFTR ICRF.** Martin, A. (Princeton Plasma Physics Lab., Princeton Univ., PO Box 451, Princeton, NJ (USA)); Fredd, E. vp of Proceedings of the 12th symposium on fusion engineering. IEEE Service Center, Piscataway, NJ (1987). DOE Contract AC02-76CH03073. (CONF-871007–: 12. symposium on fusion engineering, Monterey, CA (USA), 12-16 Oct 1987).

The RF Branch at Princeton Plasma Physics Laboratory (PPPL) is presently assembling and testing a 10 MW ICRF RF heating system for TFTR. This system uses upgraded high power sources that were originally operated with the PLT Tokamak. The flexibility of rf as a source of heating power has permitted the PLT sources to be used on TFTR by simply installing low loss transmission lines to transfer the power over approximately 800 feet from the existing PLT installation to the TFTR test cell. Four rf generators will feed four transmission lines and provide power to the two dualstrap launchers

within the TFTR vacuum vessel. The critical interface system for matching the generators to the rf launchers is described. This paper discusses the hardware in the RFE and the system capabilities and limitations for matching at the multimegawatt power level. The matching algorithm is discussed for both a fully automated, computer controlled operation and a manual mode of operation.

8993 Design of an ion cyclotron resonance heating system for the compact ignition Tokamak. Yugo, J.J. (Oak Ridge National Lab., PO Box Y, Oak Ridge, TN (USA)); Goranson, P.L.; Swain, D.W.; Baity, F.W.; Vesey, R. vp of Proceedings of the 12th symposium on fusion engineering. IEEE Service Center, Piscataway, NJ (1987). DOE Contract AC05-84OR21400. (CONF-871007–: 12. symposium on fusion engineering, Monterey, CA (USA), 12-16 Oct 1987).

The Compact Ignition Tokamak (CIT) requires 10 20 MW of ion cyclotron resonance heating (ICRH) power to raise the plasma temperature to ignition. The initial ICRH system will provide 10 MW of power to the plasma, utilizing a total of six rf power units feeding six current straps in three ports. The system may be expanded to 20 MW with additional rf power units, antennas, and ports. Plasma heating will be achieved through coupling to the fundamental ion cyclotron resonance of a ^{3}He minority species (also the second harmonic of tritium). The proposed antenna is a resonant double loop (RDL) structure with vacuum, shorted stubs at each end for tuning and impedance matching. The antennas are of modular, compact construction for installation and removal through the midplane port. Remote maintainability and the reactorlike operating environment have a major impact on the design of the launcher for this machine.

8994 U.S. contribution to the International Tokamak Reactor workshop: Phase 2a, part 3, 1985-1987. . Stacey, W.M. Jr. (Georgia Inst. of Tech., Atlanta, GA (USA). Nuclear Engineering Dept.); Ehst, D.A.; Smith, D.L.; Flanagan, C.A.; Peng, Y.K.M.; Spampinato, P.T.; Pomphrey, N.; Post, D.E. *Fusion Technology (USA)*, 15(4): 1485-1506 (Jul 1989).

This paper discusses the recent phase of the International Tokamak Reactor Workshop. It focused on the analysis of critical technical issues, evaluation of innovations, analysis of national engineering test reactor designs, and assessment of the supporting data base for a tokamak engineering test reactor.

8995 Stress-related problems in tokamak fusion reactor first walls. Majumdar, S. (Argonne National Lab., IL (USA)); Pai, B.K. *Fusion Technology (USA)*, 15(4): 1560-1565 (Jul 1989).

Fracture and deformation problems anticipated for the first wall of a future steady-state fusion power reactor are discussed. The stress sources considered are surface heat flux, irradiation-induced creep and swelling, and coolant pressure. Simple examples, such as a beam or a plate, as well as finite element analyses of more realistic structures from recent design studies, are used to explain the problems that are anticipated. Detailed two- and three-dimensional finite element analyses of a grooved first wall are presented to show that grooving the first wall is a potential solution for high thermal stress.

99 GENERAL AND MISCELLANEOUS

8996 (EUR–11783) **European institute for transuranium elements. Annual report 1987.** (Commission of the European Communities, Karlsruhe (DE). European Inst. for Transuranium Elements). Commission of the European Communities, Luxembourg (Luxembourg). 1988. 259p. Available from NTIS (US Sales Only), PC A12/MF A01.

The Report covers work done in the field of operation limits of nuclear fuels, transient behaviour of oxide fuels and fission product release under severe fuel damage conditions, actinide cycle safety, actinide research, safeguards reactor safety waste management and radiation protection.

8997 (INIS-mf–11560) **Annual report 1988-89.** Department of Atomic Energy, Bombay (India). 1989. 138p. Order Number DE90608904. Available from NTIS (US Sales Only), PC A07/MF A01 - OSTI; INIS.

The performance and activities of the Department of Atomic Energy during the financial year 1988-89 are described in the chapters entitled as: (1) General Survey, (2) Nuclear Power, (3) Research and Development, (4) Regulations and Safety Functions, (5) Public Sector Undertakings, and (6) Other Activities. Main thrust of the activities is directed towards nuclear power generation and use of radiations and radioisotopes in industry, agriculture and medicine. Some of the highlights of the year are: (1) a decision of the Government of India to set up 10 indigenous nuclear power reactors with a cumulative capacity of 4000 MWe, (2) an agreement with USSR for construction of two PWR type units each of 1000 MWe capacity, (3) attainment of criticality by the Unit-1 of Narora Atomic Power Station, (4) gross generation of 6065 million units of electric power during 1988 by three nuclear power stations at Tarapur, Rawatbhata and Kalpakkam, (5) location of additional reserves of uranium in Meghalaya, Andhra Pradesh and Bihar, (6) identification of new uraniferous zones in various states of India, (7) carrying out off-site emergency exercises at nuclear power plant sites. (M.G.B.).

8998 (LA-UR–86-2600, pp. 2-47) **The natural heat engine.** Wheatley, J.C.; Swift, G.W.; Migliori, A. Los Alamos National Lab., NM (USA). Fal 1986. In *Los Alamos science, Number 14.* Order Number DE87003612. Available from NTIS, PC A06/MF A01.

Heat engines are a compromise between the crisp ideals discussed in thermodynamic textbooks and the clanking, hissing realities of irreversible processes. This compromise produces wonderful machines, such as the automobile engine and the household refrigerator. In designing real devices, the goal is not to approach thermodynamic ideals by reducing irreversibilities but to balance cost, efficiency, size, power, reliability, simplicity, and other factors important to the needs of particular applications. Simplicity is the most striking feature of a natural engine, a reciprocating heat engine with no moving parts. The basic operating cycle of the natural engine is so straightforward it can be applied to a wide variety of systems with working media that range from air to paramagnetic disks. Although the natural engine is new in concept, the underlying thermodynamic principles and processes are shared with conventional engines, such as the Stirling and Rankine engines. To set the stage for natural engines, few conventional idealized thermodynamic cycles and the practical engines they suggest are discussed.

8999 (LA-UR–86-2600, pp. 96-107) **Metropolis, Monte Carlo, and the Maniac.** Anderson, H.L. Los Alamos National Lab., NM (USA). Fal 1986. In *Los Alamos science, Number 14.* Order Number DE87003612. Available from NTIS, PC A06/MF A01.

In September 1985 more than one hundred researchers from around the world met in Los Alamos for a four-day conference, in honor of Nick Metropolis, on the frontiers of quantum Monte Carlo. One of the speakers was Herb Anderson, from the Laboratory's Physics Division. Anderson's presentation was a fascinating reminiscence about the first modern calculating machines and the scientists who used them, about the intellectual ferment in the physics community that began early in this century and still continues, and about Nick Metropolis and the MANIAC. Metropolis first assignment was to develop equations of state for materials at high temperatures, pressures, and densities. Over the years Metropolis turned increasingly to mathematics and computer design, and by 1948 he was leader of a Los Alamos team that designed and built the MANIAC, one of the first electronic digital computers. Metropolis was also involved in the development of an importance-sampling scheme, called the Metropolis algorithm, that improves the effectiveness of the Monte Carlo method. In the past twenty years his work has included nonlinear problems and combinatorial theory as well as Monte Carlo calculations.

9000 (RISO-M–2767) **The contribution of Risoe National Laboratory to the research and development programs of the Danish Ministry of Energy: Status December 1988.** Skjerk Christensen, P.; Petersen, S. (eds.). Risoe National Lab., Roskilde (Denmark). Apr 1989. 83p. (In Danish). Order Number DE90610990. Available from NTIS (US Sales Only), PC A05/MF A01 - OSTI; INIS.

Since 1978 Risoe has been responsible for a number of projects in the research and development programs of the Danish Ministry of Energy. This report gives a review of current and finished projects. All current projects are described briefly, stating status and results obtained, while the results of finished projects are described in

more detail. Risoe's contribution to the organization and the administration of the programs is mentioned. Finally a list of references is given. (author) 4 tabs., 22 ills., 33 refs.

9901 Management

Refer also to citation(s) 7668

9001 (IAEA-INFCIRC–370) **Rules regarding voluntary contributions to the Agency.** International Atomic Energy Agency, Vienna (Austria). Nov 1989. 4p. Order Number DE90612718. Available from NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS.

The texts of the following Rules Regarding Voluntary Contributions to the Agency are reproduced: 1. Rules to Govern the Acceptance of Gifts of Services, Equipment and Facilities (adopted by the Board of Governors on 13 June 1989); 2. Rules Regarding the Acceptance of Voluntary Contributions of Money to the Agency (approved by the General Conference on 29 September 1989).

9002 (INS-R–332) **Nuclear Physics Group progress report: January-December 1983.** Coote, G.E. (ed.);. Department of Scientific and Industrial Research, Lower Hutt (New Zealand). Inst. of Nuclear Sciences. Feb 1985. 34p. Order Number DE90612728. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

This report summarises the work of the Nuclear Physics Group of the Institute of Nuclear Sciences during the period January-December 1983. Commissioning of the EN-tandem electrostatic accelerator continued, with the first proton beam produced in June. Many improvements were made to the vacuum pumping and control systems. Applications of the nuclear microprobe on the 3MV accelerator continued at a good pace, with applications in archaeometry, dental research, studies of glass and metallurgy. 18 refs; 7 figs; 1 table.

9003 (RISO-M–2783) **Health Physics Department. Annual progress report 1 January - 31 December 1988.** Risoe National Lab., Roskilde (Denmark). Jun 1989. 26p. Order Number DE90610992. Available from NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS.

The report describes the work of the Health Physics Department at Risoe during 1988. The activities cover dosimetry, instrumentation, radioecology, risk by nuclear activities and nuclear emergency preparedness. Lists of staff and publications are included. The emphasis in the report has been placed on basic research and contractual work. However, service functions do constitute a substantial work load for the department. (author).

9004 (WHC-SP–0446) **Physical and electrical standards laboratory general operating procedures.** Bongers, J.E. Westinghouse Hanford Co., Richland, WA (USA). Mar 1989. 68p. Sponsored by U.S. DOE Environment Health & Safety. DOE Contract AC06-87RL10930. Order Number DE90003515. Available from NTIS, PC A04/MF A01 - OSTI.

This document contains various procedures used in the operation of the Westinghouse Hanford Standards Laboratory. These procedures consist of the following titles: Organization, Operating Directives and Traceability, Preparation and Control of Operating Procedures, Selection and Qualification of Standards Laboratory Personnel, Environmental Guides and Considerations for the Standards Laboratory, Calibration Recall Program, Calibration Reports and Labels, Calibration Stamps, Quality Assurance Records, Nonconforming Equipment in the Standards Laboratory, Receiving/Shipping Instructions, Shipment of Measuring and Test Equipment at Hanford, Offsite Shipment of Standards, and Offsite Shipment of Measuring and Test Equipment.

9902 Mathematics and Computers

Refer also to citation(s) 6501, 6583, 6838, 6954, 7047, 7097, 7236, 7318, 7457, 7458, 7459, 7484, 7497, 7524, 7526, 7527, 7546, 7549, 7552, 7560, 7561, 7563, 7564, 7565, 7567, 7576, 7578, 7579, 7580, 7583, 7589, 7591, 7592, 7595, 7596, 7606, 7607, 7610, 7619, 7731, 7753, 7756, 7767, 7813, 7815, 7820, 7822, 7827, 7860, 7862, 7922, 8114, 8159, 8174, 8192, 8193, 8196, 8202, 8226, 8352, 8358, 8361, 8362, 8363, 8634, 8660, 8675, 8852, 8853, 8882, 8900, 8911, 8949, 8957, 8968, 8970, 8971, 8974, 8978, 9024

9005 (BNL–43477) **Solving time harmonic wave problems on vector processors.** Goldstein, C.I.;. Brookhaven National Lab., Upton, NY (USA). [1989]. 15p. Sponsored by U.S. DOE Energy Research; National Science Foundation. DOE Contract AC02-76CH00016. (CONF-8903179–1: 2. IMACS symposium on computational acoustics, Princeton, NJ (USA), 15-17 Mar 1989). Order Number DE90003956. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The numerical solution of multi-dimensional Helmholtz and related boundary value problems is important in various acoustic models. A great deal of research has previously been done in connection with the development of radiation boundary conditions, as well as finite difference and finite element discretizations of the boundary value problem and the solution of the resulting sparse, indefinite, non-selfadjoint system of linear equations. This includes the development, analysis and implementation of a preconditioned conjugate gradient iterative method applied to the normal equations (PCGN). Due to the large number of waves that must be resolved, the use of vector and parallel supercomputers is essential for the practical solution of large problems. The present work addresses various issues dealing with the effective solution of two- and three-dimensional Helmholtz problems on vector computers. In particular, a Helmholtz solver previously developed by the author has been vectorized and implemented on an IBM 3090-180 with vector facility at Brookhaven National Laboratory. The code can treat Helmholtz type problems with variable index of refraction and different radiation conditions in Cartesian and cylindrical waveguides as well as in the exterior of a bounded obstacle. It has also been applied to three-dimensional parabolic type wave models. Most of the computation involves the solution of the resulting large, sparse system of linear equations. Both the PCGN algorithm and multigrid preconditioner have been completely vectorized. In this paper, we discuss various aspects of the numerical algorithm and discuss the issues involved in the vectorization of the code. Timing results on the IBM 3090 are also given and demonstrate that the code vectorizes very well. 17 refs., 2 tabs.

9006 (CONF-900116–2) **Neural network models for Linear Programming.** Culioli, J.C. (Oak Ridge National Lab., TN (USA)); Protopopescu, V.; Britton, C.; Ericson, N. Oak Ridge National Lab., TN (USA). 1989. 5p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. DARPA1868-A037-A1. From International joint conference on neural networks; Washington, DC (USA); 15-19 Jan 1990. Order Number DE89015974. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The purpose of this paper is to present a neural network that solves the general Linear Programming (LP) problem. In the first part, we recall Hopfield and Tank's circuit for LP and show that although it converges to stable states, it does not, in general, yield admissible solutions. This is due to the penalization treatment of the constraints. In the second part, we propose an approach based on Lagragrange multipliers that converges to primal and dual admissible solutions. We also show that the duality gap (measuring the optimality) can be rendered, in principle, as small as needed. 11 refs.

9007 (CONF-900116–3) **A neural network for bounded linear programming.** Culioli, J.C. (Oak Ridge National Lab., TN (USA)); Protopopescu, V.; Britton, C.; Ericson, N. Oak Ridge National Lab., TN (USA). 1989. 5p. Sponsored by U.S. Department of Defense. DOE Contract AC05-84OR21400. DARPA1868-A037-A1. (CESAR–89/33). From International joint conference on neural networks; Washington, DC (USA); 15-19 Jan 1990. Order Number DE89015975. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The purpose of this paper is to describe a neural network implementation of an algorithm recently designed at ORNL to solve the Transportation and the Assignment Problems, and, more generally, any explicitly bounded linear program. 9 refs.

9008 (DOE/SR–8003-Vol.2) **Performance criteria and evaluation system for occupational radiation safety at Department of Energy sites: Volume 2, Reference manual: Version B.1.0.** NUS

Corp., Aiken, SC (USA). Aug 1989. 334p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-87SR15107. Order Number DE90003078. Available from NTIS, PC A15/MF A01; OSTI; Order software packages from National Energy Software Center, Argonne National Laboratory, 9800 South Cass Avenue, Argonne, IL 60439. Order documentation without complete package from NTIS.; GPO Dep.

Volume 2, the Reference Manual, is an essential tool for the Performance Criteria and Evaluation System (PCES). Appendixes A through I present useful and important details on the data base criteria. They are the resources to tap the large number of radiation safety requirements applicable to DOE sites and programs. Although the text of the criteria is not reproduced here, all the rest of the information on each criterion is presented.

9009 (LA-UR–89-1383) **Complex availability problems solved with simulation.** Schroeder, G.J. (Los Alamos National Lab., NM (USA)); Johnson, M.M. Los Alamos National Lab., NM (USA). 1990. 20p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-36. (CONF-900108–1: Reliability and maintainability symposium, Los Angeles, CA (USA), Jan 1990). Order Number DE89012610. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

System owners and operators are increasingly emphasizing the actual amount of time equipment is capable of performing its intended function. For military systems, added complexity, longer service life requirements, reduced periodic maintenance, and less frequent checkouts are increasing system availability requirements. However, these factors compound the difficulty in estimating the system's true availability. With dormant or semi-dormant systems, the amount of time a system "appears" available may differ form the "real" availability. The difference in "real" and "apparent" availability is often the result of a transition from an operational but dormant state to an inoperational but dormant state. The major contributions from this research are: the development of the concept of "complex" availability that applies to systems which combine two or more elements of instantaneous, mission system, or steady-state availability; and the development of modeling technique to estimate the "real" availability for a system which involves "complex" availability. 28 refs., 2 figs.

9010 (LA-UR–89-3244) **Experiences with knowledge-base and large database integration.** Michelsen, C.; Smith, D.; McGrath, G. Los Alamos National Lab., NM (USA). [1989]. 23p. Sponsored by U.S. DOE Management & Administration. DOE Contract W-7405-ENG-36. (CONF-900137–1: Hawaii international conference on systems sciences: massive databases and I11-defined objects, Kailua-Kona, HI (USA), 2-5 Jan 1990). Order Number DE90000686. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This paper will discuss the integration of several knowledge-bases (network data structures providing inheritance and rule-base definition/execution) and a large database in the context of a manufacturing simulation. The simulation represents the production activities at numerous facilities and is used to determine if a production schedule can be satisfied. The simulation is supplied with data from a large relational database which includes production facility characteristics as well as piece part information. The simulation is currently in use with new functionality being incorporated at this time. This paper will also illustrate the problems inherent in loosely-coupled knowledge-base and database data exchanges. 14 refs., 5 figs.

9011 (LA-UR–89-3679) **A 3-D measurement system using object-oriented FORTH.** Butterfield, K.B. Los Alamos National Lab., NM (USA). [1989]. 8p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-36. (CONF-8911140–1: 1989 FORML conference, Pacific Grove, CA (USA), 24-26 Nov 1989). Order Number DE90003393. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Discussed is a system for storing 3-D measurements of points that relates the coordinate system of the measurement device to the global coordinate system. The program described here used object-oriented FORTH to store the measured points as sons of the measuring device location. Conversion of local coordinates to absolute coordinates is performed by passing messages to the point objects. Modifications to the object-oriented FORTH system are also described. 1 ref.

9012 (ORNL/CSD/TM–265) **EZVIDEO, FORTRAN graphics routines for the IBM AT.** Patterson, M.R.; Holdeman, J.T.; Ward, R.C.; Jackson, W.L. Oak Ridge National Lab., TN (USA). Oct 1989. 29p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004409. Available from NTIS, PC A03/MF A01; OSTI; Order software packages from National Energy Software Center, Argonne National Laboratory, 9800 South Cass Avenue, Argonne, IL 60439. Order documentation without complete package from NTIS.; GPO Dep.

Report includes 1 diskette designed to operate on an IBM PC or compatible equipment.

A set of IBM PC-based FORTRAN plotting routines called EZVIDEO is described in this report. These routines are written in FORTRAN and can be called from FORTRAN programs. EZVIDEO simulates a subset of the well-known DISSPLA graphics calls and makes plots directly on the IBM AT display screen. Screen dumps can also be made to an attached LaserJet or Epson printer to make hard copy without using terminal emulators. More than forty DISSPLA calls are simulated by the EZVIDEO routines. Typical screen plots require about 10 seconds (s), and good hard copy of the screen image on a laser printer requires less than 2 minutes (min). This higher-resolution hard copy is adequate for most purposes because of the enhanced resolution of the screen in the EGA and VGA modes. These EZVIDEO routines give the IB, AT user a stand-alone capability to make useful scientific or engineering plots directly on the AT, using data generated in FORTRAN programs. The routines will also work on the IBM PC or XT in CGA mode, but they require more time and yield less resolution. 7 refs., 4 figs.

9013 (ORNL/TM–10823) **$T_EX$nical typesetting: A guide through the TEX typesetting program.** Ketterer, S.P. Oak Ridge National Lab., TN (USA). Oct 1989. 156p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004398. Available from NTIS, PC A07/MF A01 - OSTI; GPO Dep.

This manual is designed as a comprehensive hands-on instructional manual for learning the T_EX* computer typesetting program in a classroom environment. Each section presents a new concept in careful detail, concluding with an exercise (T_EXercise) to reinforce the learning of the concept. The manual introduces the novice T_EX user to the program's basic command structure, along with the concepts of grouping, producing accents, making font changes, and generating mathematical symbols. The T_EXercises guide the new user in generating text containing footnotes, multilevel lists, and hanging indentations, as well as in magnifying text for viewgraphs. Once the basic text generation is defined, the more advanced topics of formatting math equations and tables are explained. A full range of math capabilities is presented — beginning with simple one-line equations, progressing through complex numbered and aligned equations, and concluding with matrices. The sections on table generation present the basic concepts in T_EX's table-formatting program and then build on them. The new user first learns to construct simple tables, and with careful explanations and guidance, learns to add one new table enhancement at a time. By the conclusion of these sections, the user can construct tables with horizontal and vertical rules and with column entries that are paragraphs. 1 ref.

9014 (ORNL/TM–11375) **PVM [Parallel Virtual Machine]: A framework for parallel distributed computing.** Sunderam, V.S. (Emory Univ., Atlanta, GA (USA). Dept. of Mathematics and Computer Science). Oak Ridge National Lab., TN (USA). [1989]. 28p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004390. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The PVM system is a programming environment for the development and execution of large concurrent or parallel applications that consist of many interacting, but relatively independent, components. It is intended to operate on a collection of heterogeneous computing elements interconnected by one or more networks. The participating processors may be scalar machines, multiprocessors, or special-purpose computers, enabling application components to execute on the architecture most appropriate to the algorithm. PVM provides a straightforward and general interface that permits the description of

various types of algorithms (and their interactions), while the underlying infrastructure permits the execution of applications on a virtual computing environment that supports multiple parallel computation models. PVM contains facilities for concurrent, sequential, or conditional execution of application components, is portable to a variety of architectures, and supports failure detection (and certain forms of recovery) at the process and processor levels. 16 refs., 5 figs.

9015 (SAND–89-1608C) **Digital system for monitoring and controlling remote processes.** Roach, D.P. Sandia National Labs., Albuquerque, NM (USA). [1989]. 19p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-891208–26: Winter annual meeting of the American Society of Mechanical Engineers, San Francisco, CA (USA), 10-15 Dec 1989). Order Number DE90003935. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The need to operate increasingly complex and potentially hazardous facilities at higher degrees of efficiency can be met through the development of automated process control systems. The availability of microcomputers capable of interfacing to data acquisition and control equipment results in the possibility of developing such systems at low investment costs. In this paper, an automated control system is described which maintains a constant or time varying pressure in a pressure vessel. Process control data acquisition and analysis is carried out using a commercially available microcomputer and data scanner interface device. In this system, a computer interface is developed to allow precision positioning of custom designed proportional valves. Continuous real-time process control is achieved through a direct digital control algorithm. The advantages to be gained by adapting this system to other process control applications is discussed. The modular design and ability of this system to operate many types of hardware control mechanisms makes it adaptable to a wide variety of industrial applications. 8 refs., 11 figs.

9016 (SAND–89-1916C) **One-class generalization in second-order backpropagation networks for image classification.** Moya, M.M. (Sandia National Labs., Albuquerque, NM (USA)); Hostetler, L.D. Sandia National Labs., Albuquerque, NM (USA). [1989]. 5p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-900116–1: International joint conference on neural networks, Washington, DC (USA), 15-19 Jan 1990). Order Number DE89015845. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

In an earlier paper, we reported that it is possible to train a first-order multi-layer feedforward network with backpropagation to classify raw 8-bit images of vehicles. We concluded that a linear feedforward network is capable of within-class generalization when trained with perspective views taken every 10°, but it is incapable of one-class generalization. This paper describes the results of a set of experiments to train a feedforward network with second-order inputs to perform one-class classification on image data. We compare the results of the first-order network and the second-order network and show that the second order network is better able to generalize as a one-class classifier. 7 refs., 6 figs.

9017 (SAND–89-2531) **User's guide for Department 9140 CAE workstations.** Salguero, D.E. Sandia National Labs., Albuquerque, NM (USA). 1 Mar 1989. 116p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. Order Number DE90004989. Available from NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The purpose of this report is to provide some basic information to beginning users of Department 9140's Computer-Aided Engineering (CAE) workstations. These workstations are all Digital Equipment Corporation (DEC) color VAXstations, and they use the VAX/VMS operating system. This manual shows users how to boot the workstations, login, use the window interface, and use some basic VMS commands. It also discusses some of the CAE software available on the workstations, such as ANVIL-5000. References are given so users can get additional information. 25 refs., 27 figs.

9018 (SAND–89-2581C) **Asymptotically fast triangularization of matrices over rings.** Hafner, J.L. (IBM Almaden Research Center, San Jose, CA (USA)); McCurley, K.S. Sandia National Labs., Albuquerque, NM (USA). [1989]. 8p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-900148–1: ACM/SIAM symposium on discrete algorithms, San Francisco, CA (USA), 20-24 Jan 1990). Order Number DE90003161. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

We consider problems related to the computation of Hermite and Smith normal forms of integer matrices, and more generally matrices over a principal ideal ring. First, we show that if the matrix A is m x n, with rank m and integer entries bounded in absolute value by T, then the Hermite normal form can be computed in $O(m^2nB(m\ log(mT)))$ bit operations, where B(t) denotes a function that bounds the time required to perform the extended Euclidean algorithm on two t bit integers. Furthermore we show that the Smith normal form can be computed in $O(m^3nB(m\ log(mT))log(mT))$ bit operations. In the second part of the paper we apply fast matrix multiplication techniques to the problem of triangularizing a matrix over a ring using elementary column operations. We also prove that matrix inversion and multiplication are equivalent in complexity over an arbitrary Principal Ideal Domain, generalizing a result of Bunch and Hopcroft. We then apply our general results to obtain an algorithm for triangularizing integer matrices that has a faster running timer than the known Hermite normal form algorithms. The triangular matrix that is computed has small entries like the Hermite normal form, and will suffice for many applications. In the last part of the paper, we discuss a probabilistic method for calculating Smith normal forms. 17 refs.

9019 (SAND–89-2592C) **An iterative Bayes procedure for reliability assessment.** Prairie, R.R. (Sandia National Labs., Albuquerque, NM (USA)); Zimmer, W.J. Sandia National Labs., Albuquerque, NM (USA). 1990. 10p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-900108–2: Reliability and maintainability symposium, Los Angeles, CA (USA), Jan 1990). Order Number DE90002106. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

In component reliability assessment programs, three major sources of data are available for reliability assessment: a development program, production data, and field test data. In practice, reliability assessments are required at the end of each stages, and a common method of assessment is to simply combine the test data and provide a pooled estimate. The method suggested in this paper is Bayesian in that the uncertainty about the unreliability is expressed by means of a prior distribution with a specified upper limit. The method is hierarchical Bayes in that the uncertainty about the limit of that prior distribution is also expressed by means of a prior distribution. The data from the development program are incorporated with the prior on the unreliability and with the prior on the upper limit of the prior to obtain a new prior on unreliability. The production data are then used to obtain a revised estimate of the unreliability as well as a modified value for the limit of the prior distribution. This same concept will be carried through when the field data are obtained. The result is a final Bayesian reliability assessment that is iterative in nature and incorporates in a sequential fashion data from each of the three stages common to a component development, production, and surveillance program. 4 refs., 2 tabs.

9020 (SAND–89-2712) **CAE [computer-aided engineering] tools' limitations case study: An SSI [small scale integrated] design to an ASIC [application specific integrated circuit].** Everts, J. Sandia National Labs., Albuquerque, NM (USA). [1989]. 5p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC04-76DP00789. (CONF-900146–1: 1990 DAZIX Users' Group meeting, San Francisco, CA (USA), 23-25 Jan 1990). Order Number DE90002902. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Every computer-aided engineering (CAE) tool has its limitations and shortcomings. Knowing where the pitfalls lie and how to get around them is extremely valuable. This paper takes a look at the problems and limitations encountered using the Daisy Systems suite of digital design tools (on a Logician 386 and a PKK386 MegaLogician, running DNIX 5.02A) to redesign a 169 small scale integrated (SSI) component design into an application specific integrated circuit (ASIC) gate array. Deficiencies were found in the libraries, ACE, MDLS, DTA, MCFS, and the Hotline support. Some solutions and workarounds to these deficiencies are presented.

9021 **Start/Pat: A parallel-programming toolkit.** . Appelbe, B. (Georgia Inst. of Tech., Atlanta, GA (USA)); Smith, K.; McDowell, C.

IEEE Software (Institute of Electrical and Electronics Engineers) (USA), : 29-40 (Jul 1989).

How can you make Fortran code parallel without isolating the programmer from learning to understand and exploit parallelism effectively. With an interactive toolkit that automates parallelization as it educates. This paper discusses the Start/Pat toolkit.

9022 Faust: An integrated environment for parallel programming. . Guarna, V.A. Jr. (Illinois Univ., Urbana, IL (USA)); Gannon, D.; Jablonowski, D.; Malony, A.D.; Gaur, Y. *IEEE Software (Institute of Electrical and Electronics Engineers) (USA),* : 20-28 (Jul 1989).

Designed for the development of large, scientific applications, Faust includes several new tools and integrates existing tools. Some components will be ready for public distribution this year. The design and applications of Faust is discussed in this article.

9023 Maximizing long-term gas industry profits in two minutes in Lotus using neural network methods. Werbos, P.J. (Energy Analysis and Forecasting Div., Energy Information Administration, Washington, DC (US)). *IEEE (Institute of Electrical and Electronics Engineers) Transactions on Systems, Man, and Cybernetics (USA),* 19(2): 315-333 (Mar 1989).

Generalized methods, commonly used in neural network research, have made it possible for the Energy Information Administration (EIA) to solve a gas industry optimization problem on a personal computer that would previously have required a mainframe computer because of the run time required. The resulting model was used to produce EIA's official energy forecasts published in 1988. It is shown how backpropagation - one of the basic methods used to adapt artificial neural networks - can be used by modelers with no special training in neurocomputing. Earlier applications of backpropagation to modeling and to EIA problems are reviewed that antedate the practical applications of backpropagation to modeling and to EIA problems are reviewed that antedate the practical applications to neural networks. The relations between backpropagation, the current EIA model, and economic issues related to modeling and the gas industry are discussed. Among these issues are optimization subject to constraints, and competition and efficiency in gas supply. It is also shown how more recent formulations of backpropagation are a special case of the formulation given here, further work discussing the relevance of the original formulation to the mammalian brain is cited.

9024 Random number generators for MIMD parallel processors. Percus, O.E. (New York Univ., NY (USA)); Kalos, M.H. *Journal of Parallel and Distributed Computing (USA),* 6(3): 477-497 (1989).

The authors discuss and analyze issues related to the design of pseudorandom number generators (prn's) for MIMD (multiple instruction stream/multiple data stream) parallel processors, which are very well suited to Monte Carlo calculations. They are concerned with ensuring reproducibility of runs, providing very long sequences, and assuring an adequate degree of independence of the parallel streams.

9903 Information Handling

Refer also to citation(s) 8160, 8234, 8752, 9022

9025 (CONF-8910314–2) **Knowledge-based decision support for travel formulation and analysis.** Phifer, M.S.; Jones, K.A.; Gadagkar, H.; Emrich, M.L. Oak Ridge National Lab., TN (USA). [1989]. 10p. Sponsored by U.S. DOE Energy Research; U.S. Department of the Treasury. DOE Contract AC05-84OR21400. 1925-B034-A1. From 4. international symposium on methodologies for intelligent systems (ISMIS); Charlotte, NC (USA); 13-14 Oct 1989. Order Number DE90003694. Available from NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Tools and methodologies that support efficient and rapid financial decision making are limited. One responsibility of the Financial Management Service (FMS) of the US Department of the Treasury involves decision making associated with government travel. To aid FMS personnel, two prototypes are being developed utilizing a fourth generation language (i.e., FOCUS) and a knowledge-based tool (i.e., Level5). One system assists with travel formulation and preparation. A companion system performs audits and financial analysis on travel data. 13 refs., 1 fig.

9026 (DOE/OR/21850–T1) **MPlus Database system: User guide.** Tresp Associates, Inc., Alexandria, VA (USA). 20 Jan 1989. 25p. Sponsored by U.S. DOE Management & Administration. DOE Contract AC05-88OR21850. Order Number DE90004146. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The MPlus Database program was developed to keep track of mail received. This system was developed by TRESP for the Department of Energy/Oak Ridge Operations. The MPlus Database program is a PC application, written in "dBase III+" and compiled with "Clipper" into an executable file. The files you need to run the MPLus Database program can be installed on a Bernoulli, or a hard drive. This paper discusses the use of this database.

9027 (ORNL/TM–11261) **Matrix reduction algorithms for GRESS [Gradient Enhanced Software System] and ADGEN [ADjoint matrix GENerator].** Horwedel, J.E. Oak Ridge National Lab., TN (USA). Nov 1989. 29p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC05-84OR21400. Order Number DE90004374. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The GRESS Version 0.0 code system was developed to automate the implementation of derivative-taking capabilities in existing FORTRAN 77 computer models. The GRESS CHAIN option is used to calculate and report first derivatives of model results with respect to user selected input data by application of the calculus chain rule. The GRESS ADjoint Matrix GENerator (ADGEN) option is used to calculate first derivatives of selected model results with respect to all input data. The first part of this paper presents the mathematical foundations and algorithms as presently implemented in GRESS Version 0.0. Examples are used to describe the implementation of both the CHAIN and ADGEN options. Due to excessive execution time and memory requirements with the CHAIN option users are often limited to propagating derivatives for just a few parameters. The ADGEN option allows an almost unlimited number of parameters (i.e., input data); however, the data storage requirement for an ADGEN application was more than 322 megabytes for a code that executes in 1 minute on a VAX 8600 computer. The purpose for this paper is to present three new algorithms that could easily be implemented in GRESS Version 0.0 to dramatically reduce he data storage requirements and execution time for application of the ADGEN option. The new algorithms are described with examples. Test versions of these algorithms were implemented and tested. The application of these algorithms to the GRESS enhancement of the PRESTO-II computer model resulted in a significant reduction in execution time and a reduction in data storage requirements from 322 megabytes to 97 megabytes without any loss in the generality of the approach. 23 refs., 14 figs., 8 tabs.

9028 (ORNL/TM–11336) **User interface techniques in the counseling module of TOPS [Transportation Operational Personal Property Standard].** Yow, T.G. Oak Ridge National Lab., TN (USA). Oct 1989. 48p. Sponsored by U.S. DOE Energy Research. DOE Contract AC05-84OR21400. Order Number DE90004385. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The Transportation Operational Personal Property Standard System (TOPS) is an automated information management system to help administer the personal property transporation program for the Department of Defense (DOD). TOPS was fielded at four prototype sites in the late summer of 1988. Prototype testing is currently underway, with system deployment scheduled for 1989. When fully deployed, TOPS will save DOD both time and money and help ensure that all shipments made by armed services personnel are handled quickly and efficiently. The success of the TOPS system depends upon several key factors. Of course, TOPS must give transportation clerks at military personal property shipping offices a tool with which they can perform their jobs with greater ease, speed, and correctness. However, before TOPS can achieve success in the field, it must first find acceptance from the transportation clerks themselves. The purpose of this document is to examine the user interface techniques used in the Counseling module of TOPS to ensure user acceptance and data base integrity, both key elements in the ultimate success of TOPS. 6 refs., 12 figs.

9029 (ORNL/TM–11373) **Sensitivity analysis of AIRDOS-EPA using ADGEN with matrix reduction algorithms.** Horwedel, J.E.; Raridon, R.J.; Wright, R.Q. Oak Ridge National Lab., TN (USA). Nov 1989. 47p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC05-84OR21400. Order Number DE90004373. Available from NTIS, PC A03/MF A01 - OSTI; GPO Dep.

ADGEN was developed to automate the calculation of sensitivities of a new model results to all input data in existing FORTRAN 77 computer models. ADGEN is now included as one of two options available to users of the Gradient Enhanced Software System (GRESS). GRESS was initially developed to automate the calculation of sensitivities of all model results to a few input parameters by application of the calculus chain rule during the forward run of the computer model. The ADGEN option automates the application of adjoint sensitivity theory to calculate first derivatives of model results to input data by first creating, and then solving, an adjoint equation for the computer model. The purpose of this report is twofold: to present the development of two algorithms that significantly improve the application of ADGEN; and, to demonstrate the application of ADGEN to the AIRDOS-EPA computer model. 18 refs., 8 tabs.

Corporate Author Index

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FG02-88ER40408	**Purdue Univ., Lafayette, IN (USA)**	
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FG02-88ER40448	**Rensselaer Polytechnic Inst., Troy, NY (USA). Dept. of Physics**	
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FG02-88ER60742	**Vermont Univ., Burlington, VT (USA). Dept. of Microbiology and Molecular Genetics**	
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FG05-83OR21390	Council of Great Lakes Governors, Chicago, IL (USA)	
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FG05-88ER13954	Texas A and M Univ., College Station, TX (USA). Dept. of Chemistry	
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FG05-88ER13975	University of South Florida, Tampa, FL (USA). Dept. of Chemistry	
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FG05-89ER40501	Virginia Univ., Charlottesville, VA (USA). Inst. of Nuclear and Particle Physics	
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	15:7104	DOE/PC/79935–12
FG22-88BC14265	Texas Univ., Austin, TX (USA). Geoscience Inst. for Oil and Gas Recovery Research	
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FG22-88PC88900	Stanford Univ., CA (USA). High Temperature Gasdynamics Lab.	
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FG22-88PC88912	California State Univ., Long Beach, CA (USA)	
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FG22-88PC88927	Massachusetts Inst. of Tech., Cambridge, MA (USA). Dept. of Chemical Engineering	
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CE-02828	15:7640	Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN			
CE-02829	15:7641	Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN			
CE-02832	15:7677	Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN			

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
CE-02834-3.2	15:7644	Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN			
CE-02836	15:7691	Canadian National Committee World Energy Conference, Suite 305, 130 Albert Street, Ottawa, ON, CAN K1P 5G4. Prices: $125.00 CAN			
CE–					
02411	15:7667	*See* EMR–EP-81-1E			
02437	15:6495	*See* ARC–CE-02437			
02657	15:6930	*See* AOSTRA–CE-02657			
02762	15:7773	*See* ACERR–CE-02762			
02774	15:6925	*See* NEB-SS–GHW-1-89-E			
02775	15:6926	*See* NEB-SS–GHW-1-89-F			
02783	15:6910	*See* ESC–CE-02783			
02785	15:6909	*See* IT–CE-02785			
02786	15:6829	*See* PCCIM–CE-02786-2.vols			
02787	15:6885	*See* IT–CE-02787			
02795	15:7700	*See* EMR/CRE–CE-02795			
02796	15:6923	*See* NEB-SS–GH-4-88			
02797	15:6924	*See* NEB-SS–GH-4-88F			
02798	15:6927	*See* NEB-SS–RH-2-88			
02799	15:7729	*See* NEB-SS–RH-2-88-F			
02801	15:6920	*See* ERCB–D89-1			
02802	15:7806	*See* ORF/ES–CE-02802			
02804	15:7621	*See* NBU/ME–180D579			
02806	15:6891	*See* ERCB–G-35			
02807	15:6921	*See* ERCB–IL88-9			
02808	15:7802	*See* MLWIA–CE-02808			
02809	15:6890	*See* ERCB–D89-8			
02811	15:6861	*See* CPA–CE-02811			
02812	15:6825	*See* CPA–CE-02812			
02818	15:7862	*See* OE–CE-02818			
02824	15:7678	*See* ERCB–AE-89-AA			
02825	15:6788	*See* EMR/CANMET–CE-02825			
02826	15:7206	*See* SU–CE-02826			
02827	15:7653	*See* CANWEC–CE-02827			
02828	15:7640	*See* CANWEC–CE-02828			
02829	15:7641	*See* CANWEC–CE-02829			
02832	15:7677	*See* CANWEC–CE-02832			
02834	15:7644	*See* CANWEC–CE-02834-3.2			
02836	15:7691	*See* CANWEC–CE-02836			
02845	15:7417	*See* TAU–CE-01344			
02846	15:6824	*See* CIM/S–CE-02846			
02849	15:7746	*See* ERCB–880953			
02850	15:6758	*See* OH/RD–712G619			
02851	15:7508	*See* OH/RD–717G620			
02905	15:7755	*See* NEB-SS–EH-2-89			
CEGB-RD-B–					
6085/R88	15:7887	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611885	
6092/R89	15:7888	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611956	
6107/R89	15:7889	NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS		DE90611886	
6108/R89	15:7890	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611887	
CEGB-RD-M–					
1773/RR88	15:7891	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611823	
1783/RR89	15:7892	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611824	
CERN–					
89-08(v.1)	15:8686	NTIS (US Sales Only), PC A20/MF A01 - OSTI; INIS		DE90611488	
89-08(v.2)	15:8687	NTIS (US Sales Only), PC A10/MF A01 - OSTI; INIS		DE90611489	
89-08(v.3)	15:8700	NTIS (US Sales Only), PC A15/MF A01 - OSTI; INIS		DE90611465	

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CESAR–					
89/33	15:9007	*See* CONF-900116–3			
CESI–					
86-9	15:7466	NTIS (US Sales Only), PC A02/MF A01		DE89761905	
86-12	15:8154	NTIS (US Sales Only), PC A02/MF A01		DE89761907	
86-13	15:8155	NTIS (US Sales Only), PC A03/MF A01		DE89761909	
86-14	15:8156	NTIS (US Sales Only), PC A02/MF A01		DE89761908	
86-19	15:7603	NTIS (US Sales Only), PC A02/MF A01		DE89761912	
87-61	15:7467	NTIS (US Sales Only), PC A03/MF A01		DE89761900	
CIEMAT–					
624	15:8092	NTIS (US Sales Only), PC A03/MF A01		DE89785675	
CIM/S–					
CE-02846	15:6824	Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8. Prices: $50.00 CAN			
CMHC–					
87E53	15:7196	PC Canada Mortgage and Housing Corporation, Annex Bldg., 628 Montreal Rd., Ottawa, ON, CAN K1A 0P7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN			
COGLA–					
89-04905	15:7740	PC Energy, Mines and Resources Canada, Communications Branch, 580 Booth St., Ottawa, Ont., CAN K1A 0E4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN			
CONF-8102119–		(McGill student conference on energy; Montreal (Canada); 11-14 Feb 1981)			
	15:7700	*See* EMR/CRE–CE-02795			
CONF-840909–		(TMS-AIME fall meeting; Detroit, MI (USA); 16-20 Sep 1984)			
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CONF-8506400–		(2. international workshop on mathematical aspects of fluid and plasma dynamics (MAFPD-2); Paris (France); 24-28 Jun 1985)			
	15:8815	*See* IPP–6/254			
CONF-851217–		(Materials Research Society meeting; Boston, MA (USA); 2-7 Dec 1985)			
	15:7924	Materials Research Society, 9800 Mc Knight Rd., Suite 327, Pittsburgh, PA 15237			
CONF-8601152–		(Seminar on the reliability of power electronic equipment; Milan (Italy); 23-24 Jan 1986)			
	15:8155	*See* CESI–86-13			
CONF-8604415–		(Meeting of the Radiotherapy Commission of Medical Physics Committee of Polish Academy of Sciences; Cracow (Poland); 29 Apr 1986)			
	15:8540	*See* INP–1331/B			
CONF-8606424–		(Meeting on the future of low voltage and medium voltage switchgear; Pavia (Italy); 16-18 Jun 1986)			
	15:8156	*See* CESI–86-14			
CONF-8608233–		(CIGRE international conference on large high voltage electric systems; Paris (France); 27 Aug - 4 sep 1986)			
	15:8154	*See* CESI–86-12			
8	15:8598	NTIS (US Sales Only), PC A02/MF A01		DE89761886	
CONF-8609450–		(87. meeting of the Italian Electrotechnical Association; Florence (Italy); 29 Sep - 3 oct 1986)			
	15:7603	*See* CESI–86-19			
CONF-8609473–		(PLEA '86 Pecs conference; No City Given (Hungary); Sep 1986)			
1	15:7197	NTIS (US Sales Only), PC A02/MF A01		DE89761960	

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
CONF-861005–		(ASME joint power generation conference; Portland, OR (USA); 19-23 Oct 1986)			
	15:7482	*See* ENEL–53-86-F			
1	15:7472	NTIS (US Sales Only), PC A02/MF A01		DE89761891	
CONF-8610270–		(2. national conference of the Canadian Wind Energy Association; Quebec (Canada); 26-28 Oct 1986)			
	15:7410	*See* CANWEA–88-06463			
CONF-8701165–		(Seminar on comparison of drying methods of wet coal and peat; Jyvaeskylae (Finland); 6 Jan 1987)			
	15:6498	*See* VTT-SYMP–98			
CONF-8704267–		(Materials Research Society symposium on plasma processing and synthesis of materials; Anaheim, CA (USA); 21 Apr 1987)			
	15:7035	Materials Research Society, 9800 Mc Knight Rd., Suite 327, Pittsburgh, PA 15237			
CONF-8704378–		(European conference on architecture; Munich (Germany, F.R.); 6-10 Apr 1987)			
1	15:7144	NTIS (US Sales Only), PC A02/MF A01		DE89761951	
CONF-8708197–		(6. international seminar on inelastic analysis and life prediction in high temperature environment; Paris (France); 24-25 Aug 1987)			
	15:8164				
CONF-8708311–		(Symposium on advances in FCC; New Orleans, LA (USA); 30 Aug - 4 sep 1987)			
	15:6858				
	15:6859				
CONF-8708312–		(Symposium on advances in naphtha reforming; New Orleans, LA (USA); 30 Aug - 4 sep 1987)			
	15:6860				
CONF-8708315–		(American Chemical Society Division of Petroleum Chemistry; New Orleans, LA (USA); 30 Aug - 4 sep 1987)			
	15:7103				
CONF-8708345–		(Annual meeting of the Phycological Society of America; Columbus, OH (USA); 9-13 Aug 1987)			
	15:8595				
CONF-8709122–		(Specialists' meeting on data for decay heat predictions; Studsvik (Sweden); 7-10 Sep 1987)			
	15:8776	*See* NEA-CRP-L–302(Rev.)			
CONF-8709252–		(International symposium on position detectors for high energy physics; Dubna (USSR); 22-25 Sep 1987)			
	15:8689	*See* JINR-D–1-13-88-172			
CONF-8709394–		(88. annual meeting of the Italian Electrotechnical Association (AEI); Catania (Italy); 27-30 Sep 1987)			
	15:7467	*See* CESI–87-61			
	15:8170	*See* ENEL–410.100-27			
CONF-871027–		(172. meeting of the Electrochemical Society; Honolulu, HI (USA); 18-23 Oct 1987)			
48	15:7633	*See* BNL–43460			
CONF-8711143–		(Symposium on multilayers: synthesis, properties and nonelectronic applications; Boston, MA (USA); 30 Nov - 4 dec 1987)			
	15:8069	Materials Research Society, 9800 Mc Knight Rd., Suite 327, Pittsburgh, PA 15237			
CONF-8711149–		(Conference on high energy radiation background in space; Sanibel Island, FL (USA); 2-5 Nov 1987)			
	15:8639				
	15:8640				
CONF-8711245–		(Workshop on computers applications for nuclear powers and industrial process plant operation and control; Rome (Italy); 19-20 Nov 1987)			
7	15:7578	NTIS (US Sales Only), PC A03/MF A01		DE89761979	

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CONF-8711333–		(Seminar on materials separation and enrichment; Goslar (Germany, F.R.); 23-24 Nov 1987)			
	15:8089	*See* INIS-mf–12023			
CONF-8803248–		(3. University of California conference on statistical mechanics; Davis, CA (USA); 27-30 Mar 1988)			
	15:8739				
CONF-8803249–		(20. session of the DVM working group on fracture mechanisms: corrosion and fracture; Frankfurt am Main (Germany, F.R.); 17-18 Mar 1988)			
	15:7901	*See* GKSS–88/E/72			
CONF-880529–		(MRS international meeting on advanced materials; Tokyo (Japan); 30 May - 3 jun 1988)			
9	15:8002	*See* LBL–25457			
CONF-8805342–		(Nordiska Geoteknikermoetet; Oslo (Norway); 13-15 May 1988)			
	15:8428	*See* NEI-SE–39			
CONF-8805343–		(Bergen conference on oil and economics; Bergen (Norway); 3-4 May 1988)			
	15:6869	*See* NEI-NO–72			
CONF-8805344–		(Chlorinated hydrocarbons conference; Stockholm (Sweden); 19 May 1988)			
	15:8586	*See* KVM–19			
CONF-8805345–		(IEA seminar on the CFC problem; Rome (Italy); 30-31 May 1988)			
	15:8379	*See* BFR-D–11-1989			
CONF-8805349–		(15. CPA (Canadian Petroleum Association) Frontier Division workshop; Fairmont (Canada); 8-11 May 1988)			
	15:6825	*See* CPA–CE-02812			
CONF-8806136–		(American Chemical Society Division of Fuel Chemistry meeting; Toronto (Canada); 5-10 Jun 1988)			
	15:6499				
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CONF-8806312–		(Symposium on coal-derived fuels - coprocessing; Toronto (Canada); 5-10 Jun 1988)			
	15:6679				
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CONF-8806313–		(Sulfur chemistry in coal; Toronto (Canada); 5-10 Jun 1988)			
	15:6695				
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CONF-8806314–		(Separation processes for coal conversion; Toronto (Canada); 5-10 Jun 1988)			
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Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
CONF-8806315–		(Storch award symposium; Toronto (Canada); 5-10 Jun 1988)			
	15:6739				
	15:6740				
	15:6742				
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CONF-8806316–		(Ash chemistry of coal; Toronto (Canada); 5-10 Jun 1988)			
	15:6683				
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	15:6816				
CONF-8806317–		(Mathematical simulation of coal conversion processes; Toronto (Canada); 5-10 Jun 1988)			
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CONF-8806318–		(Low temperature pyrolysis; Toronto (Canada); 5-10 Jun 1988)			
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CONF-8806445–		(Seminar on non-waste technology; Espoo (Finland); 20-23 Jun 1988)			
Vol.1	15:7843	*See* VTT-SYMP–102			
CONF-880807–		(4. UNITAR/UNDP international conference on heavy crude and tar sands; Edmonton (Canada); 7-12 Aug 1988)			
	15:6930	*See* AOSTRA–CE-02657			
CONF-8808122–		(8. international conference on positron annihilation; Gent (Belgium); 29 Aug - 3 sep 1988)			
18	15:8047	*See* BNL–43482			
CONF-8808141–		(3. international conference on synchrotron radiation instrumentation; Tsukuba (Japan); 29 Aug - 2 sep 1988)			
16	15:8264	*See* BNL–43573			
CONF-8808198–		(Excited baryons conference; Troy, NY (USA); 4-6 Aug 1988)			
5	15:8749	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003470	MF-413
CONF-8808279–		(11. European cosmic ray symposium; Balatonfuered (Hungary); 21-27 Aug 1988)			
	15:8621	*See* INIS-mf–11571			
	15:8622	*See* INIS-mf–11572			
CONF-8809159–		(14. world conference of the International Nuclear Target Development Society (INTDS): heavy-ion targets and related phenomena; Darmstadt (Germany, F.R.); 5-9 Sep 1988)			
	15:8263				
	15:8347				
CONF-8809221–		(International meeting on reduced enrichment for research and test reactors (RERTR); San Diego, CA (USA); 18-24 Sep 1988)			
6	15:7569	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003806	MF-525
7	15:7570	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003800	MF-525
CONF-880983–		(8. international symposium on high energy spin physics; Minneapolis, MN (USA); 12-17 Sep 1988)			
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	15:8695				
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CONF-8810356–		(3. joint US-Cern accelerator school on particle accelerators: frontiers of particle beams, observations, diagnosis, and correction; Capri (Italy); 20-26 Oct 1988)			
	15:8232	*See* INFN-LNF–89-21(P)			
	15:8233	*See* INFN-LNF–89-035(P)			
CONF-8810456–		(1. Nordic conference on sulfur dioxide and nitrogen oxide reduction in relation to combustion of solid fuels; Lyngby (Denmark); 17-18 Oct 1988)			
	15:6756	*See* NEI-DK–226			
1	15:8406	*See* STEV-FBT–89-32			
2	15:6760	*See* STEV-FBT–89-29			
CONF-881108–		(52. annual meeting of the Soil Science Society; Anaheim, CA (USA); 27 Nov - 2 dec 1988)			
	15:8103				
	15:8550				
CONF-8811294–		(IEA AFBC technical meeting; Amsterdam (Netherlands); 18-20 Nov 1988)			
1	15:8407	*See* STEV-FBT–89-33			
CONF-8811296–		(4. annual Canadian natural gas marketing conference; Calgary (Canada); 16 Nov 1988)			
	15:6910	*See* ESC–CE-02783			
CONF-881187–		(Optical fabrication and testing workshop; Santa Clara, CA (USA); 2-4 Nov 1988)			
2	15:7922	*See* UCRL–100043			
CONF-881201–		(4. international fluidised combustion conference; London (UK); 14-15 Dec 1988)			
1	15:8408	*See* STEV-FBT–89-34			
CONF-8812104–		(VDEW symposium: perspectives of electricity supply; Frankfurt am Main (Germany, F.R.); 5-7 Dec 1988)			
	15:7748	*See* INIS-mf–12033			
CONF-8812121–		(1988 materials testing conference; Bad Nauheim (Germany, F.R.); 1-2 Dec 1988)			
	15:7900	*See* GKSS–88/E/71			
CONF-8901115–		(Topical conference on electronuclear physics with internal targets; Stanford, CA (USA); 9-12 Jan 1989)			
7	15:8688	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003836	MF-413

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CONF-890299–		(AHF accelerator design workshop; Los Alamos, NM (USA); 20-25 Feb 1989)			
18	15:8271	*See* TRI-PP–89-47			
19	15:8261	*See* TRI-PP–89-44			
20	15:8228	*See* TRI-PP–89-42			
CONF-890304–		(3. ANS topical meeting on robotics and remote systems; Charleston, SC (USA); 13-16 Mar 1989)			
37	15:6957	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003055	MF-526
CONF-8903179–		(2. IMACS symposium on computational acoustics; Princeton, NJ (USA); 15-17 Mar 1989)			
1	15:9005	*See* BNL–43477			
CONF-8903180–		(Workshop on coherent structure in plasma; Nagoya (Japan); Mar 1989)			
1	15:8834	*See* GA-A–19794			
CONF-890402–		(10. international conference on fluidized-bed combustion; San Francisco, CA (USA); 30 Apr - 3 may 1989)			
9	15:8411	*See* STEV-FBT–89-38			
CONF-890422–		(International conference on municipal waste combustion; Hollywood, FL (USA); 11-14 Apr 1989)			
	15:8183	*See* CPS–40-11/14-1989E			
CONF-8904296–		(14. annual ARA congress; Los Angeles, CA (USA); 20-22 Apr 1989)			
1	15:8095	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003822	MF-401
CONF-890491–		(International conference on fifty years of research in nuclear fission; Berlin (Germany, F.R.); 3-7 Apr 1989)			
	15:8774				
	15:8777				
	15:8786				
	15:8787				
CONF-8905245–		(Advanced NATO research workshop: physical processes in hot cosmic plasmas; Sicily (Italy); May 1989)			
1	15:8661	*See* LA-UR–89-3769			
CONF-8905248–		(Prevention and treatment of groundwater and soil contamination in petroleum exploration and production; Calgary (Canada); 9-11 May 1989)			
	15:6885	*See* IT–CE-02787			
CONF-8905249–		(40. annual technical meeting of the Petroleum Society of the Canadian Institute of Mining and Metallurgy (CIM); Banff (Canada); 28-31 May 1989)			
	15:6829	*See* PCCIM–CE-02786-2.vols			
CONF-890554–		(3. world conference on neutron radiography; Osaka (Japan); 14-18 May 1989)			
3	15:7882	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003791	MF-700
CONF-890560–		(12. international conference on cyclotrons and their applications; Berlin (Germany, F.R.); 8-12 May 1989)			
4	15:8260	*See* TRI-PP–89-40			
5	15:7045	*See* TRI-PP–89-41			
6	15:8227	*See* TRI-PP–89-39			
7	15:8259	*See* TRI-PP–89-38			
8	15:8258	*See* TRI-PP–89-37			
9	15:8257	*See* TRI-PP–89-36			
10	15:8256	*See* TRI-PP–89-35			
CONF-8906180–		(U.S. EPA/ORNL workshop on municipal waste combustion: deposition, food chain impacts, uncertainty, and research needs; Cincinnati, OH (USA); 8-9 Jun 1989)			
3	15:8583	NTIS, PC A04/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003671	MF-402; MF-407
CONF-8906194–		(International meeting on physics at KAON; Bad Honnef (Germany, F.R.); 7-9 Jun 1989)			
5	15:8230	*See* TRI-PP–89-96			

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
CONF-8906255–		(6. Adriatic meeting on particle physics; Dubrovnik (Yugoslavia); 12-22 Jun 1989)			
1	15:8730	*See* IC–89/282			
CONF-8906256–		(57. military operations research symposium; Fort Leavenworth, KS (USA); 6-8 Jun 1989)			
1	15:8362	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003820	
CONF-8906257–		(1989 centennial meeting of the American Astronomical Society of the Pacific; Berkeley, CA (USA); 21-23 Jun 1989)			
1	15:8630	*See* UCRL–101851			
CONF-8906258–		(1989 NTNF oil and gas conference; Oslo (Norway); 13-14 Jun 1989)			
	15:6828	*See* NEI-NO–100			
CONF-8906262–		(Conference on gas plant optimization; Calgary (Canada); 7 Jun 1989)			
	15:6909	*See* IT–CE-02785			
CONF-890703–		(International conference on ion sources; Berkeley, CA (USA); 10-14 Jul 1989)			
29	15:8265	*See* JINR-E–9-89-491			
CONF-8907103–		(Conference on technology-based confidence building: energy and environment; Santa Fe, NM (USA); 9-14 Jul 1989)			
Exc.	15:7679	*See* LA-UR–89-3440-Exc.			
CONF-8907111–		(1. USA/USSR workshop on ferroelectricity; Boulder, CO (USA); 9-14 Jul 1989)			
1	15:8798	*See* BNL–43410			
CONF-8907149–		(SLD physics studies: SLD physics week; Kirkwood, CA (USA); 31 Jul - 4 aug 1989)			
	15:8344	*See* SLAC–354			
CONF-8907175–		(NATO advanced study institute on transport processes in porous media; Pullman, WA (USA); 9-18 Jul 1989)			
1	15:8610	*See* LBL–27879			
CONF-8907177–		(Ettore Majorana international school of subnuclear physics; Erice (Italy); 26 Jul - 3 aug 1989)			
1	15:8735	*See* LBL–27475			
CONF-890736–		(30. annual meeting of the Institute of Nuclear Materials Management; Orlando, FL (USA); 9-12 Jul 1989)			
73	15:7030	*See* SAND–89-0591C			
74	15:7029	*See* SAND–89-0590C			
CONF-890803–		(International conference on high energy accelerators; Tsukuba (Japan); 20-26 Aug 1989)			
43	15:8229	*See* TRI-PP–89-71			
44	15:8239	*See* TRI-PP–89-78			
45	15:8238	*See* TRI-PP–89-77			
46	15:8237	*See* TRI-PP–89-76			
47	15:8236	*See* TRI-PP–89-75			
48	15:8235	*See* TRI-PP–89-73			
49	15:8234	*See* TRI-PP–89-72			
CONF-8908129–		(12. workshop on nuclear physics; Iguazu Falls (Argentina); 28 Aug - 1 sep 1989)			
3	15:8778	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003796	MF-413
4	15:8767	*See* LBL–27654			
CONF-8908142–		(14. international symposium on lepton and photon interactions; Stanford, CA (USA); 7-12 Aug 1989)			
2	15:8706	*See* SLAC-PUB–5055			
CONF-8908148–		(International workshop on relativistic aspects of nuclear physics; Rio de Janeiro (Brazil); 28-31 Aug 1989)			
3	15:8773	*See* LBL–27926			
CONF-8908165–		(5. international conference on PIXE and its analytical applications; Amsterdam (Netherlands); 20-26 Aug 1989)			
2	15:8556	*See* BNL–43097			
3	15:8106	*See* BNL–43452			
CONF-8908173–		(6. Nordic meeting on nuclear physics; Kopervik (Norway); 10-15 Aug 1989)			
3	15:8771	*See* BNL–43440			

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CONF-8908177–		(24. intersociety energy conversion engineering conference; Washington, DC (USA); 6-11 Aug 1989)			
2	15:7781	NTIS, PC A02/MF A01 - OSTI		DE90003749	MF-310
CONF-8908182–		(9. session of the international seminars on nuclear war; Erice (Italy); 19-24 Aug 1989)			
2	15:8381	*See* BNL–43550			
CONF-8908189–		(Workshop on probabilistic methods in quantum field theory and quantum gravity; Cargese (France); 21-27 Aug 1989)			
1	15:8729	*See* FNAL/C–89/237-T			
CONF-8908191–		(1. ISSP international symposium on the physics and chemistry of organic superconductors; Tokyo (Japan); 27-30 Aug 1989)			
1	15:8051	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003793	MF-401
2	15:8656	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003794	MF-401
CONF-8908192–		(7. world round table conference on sintering; Herceg-Novi (Yugoslavia); 28 Aug - 1 sep 1989)			
1	15:7999	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003792	MF-404
CONF-890826–		(International nuclear physics conference; Sao Paulo (Brazil); 20-26 Aug 1989)			
	15:8751	*See* GSI–89-65(prepr.)			
CONF-890836–		(33. SPIE annual international technical symposium on optical and optoelectronic applied science and engineering; San Diego, CA (USA); 6-11 Aug 1989)			
20	15:8353	*See* BNL–42519			
21	15:8345	*See* UCRL–101246			
CONF-890901–		(14. world energy conference; Montreal (Canada); 17-22 Sep 1989)			
	15:7640	*See* CANWEC–CE-02828			
	15:7641	*See* CANWEC–CE-02829			
	15:7644	*See* CANWEC–CE-02834-3.2			
	15:7653	*See* CANWEC–CE-02827			
	15:7677	*See* CANWEC–CE-02832			
	15:7691	*See* CANWEC–CE-02836			
CONF-890902–		(198. American Chemical Society national meeting; Miami, FL (USA); 10-15 Sep 1989)			
21	15:8780	*See* LBL–27983			
CONF-890906–		(11. international vacuum congress and 7th international conference on solid surfaces; Cologne (Germany, F.R.); 25-29 Sep 1989)			
7	15:8244	*See* BNL–43353			
CONF-8909141–		(12. international meeting on reduced enrichment for research and test reactors; Berlin (Germany, F.R.); 10-13 Sep 1989)			
9	15:7579	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003801	MF-525
CONF-8909163–		(5. symposium on containment of underground nuclear detonations; Santa Barbara, CA (USA); 19-21 Sep 1989)			
11	15:8367	*See* UCRL–100960			
CONF-8909189–		(9. international symposium on pteridines and folic acids derivatives; Zurich (Switzerland); 3-8 Sep 1989)			
3	15:8484	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003702	MF-408
CONF-8909233–		(Workshop on towards establishing b factory; Syracuse, NY (USA); 6-9 Sep 1989)			
2	15:8255	*See* SLAC-PUB–5127			
CONF-8909273–		(Symposium in honor of Felix Boehm; Pasadena, CA (USA); 7-9 Sep 1989)			
1	15:8703	*See* LA-UR–89-4026			
CONF-8909274–		(NATO ARW - the physics and chemistry of carbides, nitrides, and borides; Manchester (UK); 18-22 Sep 1989)			
1	15:8017	*See* SAND–89-1791C			
CONF-8909275–		(23. ESLAB symposium on X-ray astronomy; Bologna (Italy); 13-20 Sep 1989)			
1	15:8634	*See* UCRL–102238			
2	15:8632	*See* UCRL–102003			

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CONF-8909276–		(6. Cambridge workshop on cool stars, stellar systems and the sun; Seattle, WA (USA); 11-14 Sep 1989)			
1	15:8625	*See* LA-UR–89-3788			
CONF-8909278–		(3. technical conference of the south Saskatchewan section of the Petroleum Society of CIM; Regina (Canada); 25-27 Sep 1989)			
	15:6824	*See* CIM/S–CE-02846			
CONF-890946–		(3. meeting on defect recognition and image processing in semiconductors (DRIP-3); Yokohama (Japan); 17-22 Sep 1989)			
3	15:8058	*See* LBL–27886			
CONF-891001–		(International conference on coal science; Tokyo (Japan); 23-27 Oct 1989)			
11	15:6511	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004143	MF-108
CONF-891007–		(13. IEEE symposium on fusion engineering; Knoxville, TN (USA); 2-6 Oct 1989)			
105	15:8930	*See* GA-A–19759			
106	15:8931	*See* GA-A–19760			
107	15:8928	*See* GA-A–19743			
108	15:8929	*See* GA-A–19745			
99	15:8927	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003768	MF-420
CONF-891013–		(6. symposium on separation science and technology for energy applications; Knoxville, TN (USA); 22-27 Oct 1989)			
9	15:8094	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003714	MF-401
CONF-8910192–		(2. DOE natural phenomena hazards mitigation conference; Knoxville, TN (USA); 3-5 Oct 1989)			
17	15:7031	*See* SAND–89-0734C			
CONF-8910222–		(17. water reactor safety information meeting; Rockville, MD (USA); 23-25 Oct 1989)			
7	15:7561	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003705	
8	15:7513	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003771	
9	15:7894	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003772	
10	15:7580	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003799	MF-523
11	15:7593	*See* SAND–89-1631C			
CONF-8910227–		(50. anniversary of nuclear fission; Leningrad (USSR); 16-20 Oct 1989)			
2	15:7576	*See* BNL-NUREG–43404			
3	15:7669	*See* LBL–27859			
CONF-891024–		(The Metallurgical Society fall meeting: materials week; Indianapolis, IN (USA); 1-5 Oct 1989)			
7	15:7920	*See* SAND–89-2703C			
CONF-891031–		(Annual meeting of the Geothermal Resources Council; Santa Rosa, CA (USA); 1-4 Oct 1989)			
9	15:7237	*See* LBL–27598			
CONF-8910313–		(NSF/EPRI workshop on anomalous effects in deuterated materials; Washington, DC (USA); 16-18 Oct 1989)			
1	15:8937	*See* LA-UR–89-3946			
CONF-8910314–		(4. international symposium on methodologies for intelligent systems (ISMIS); Charlotte, NC (USA); 13-14 Oct 1989)			
2	15:9025	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003694	MF-405
CONF-8910319–		(21. international thermal conductivity conference; Lexington, KY (USA); 15-18 Oct 1989)			
1	15:8052	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90001733	MF-410
CONF-8910320–		(Workshop on primordial nucleosynthesis; Chapel Hill, NC (USA); 6-8 Oct 1989)			
1	15:8633	*See* UCRL–102181			
CONF-8910322–		(IDEAS/CAEDS users conference; Cincinnati, OH (USA); 3-5 Oct 1989)			
1	15:8222	*See* BNL–43439			
CONF-8910328–		(2. Brazilian Congress of Geochemistry; Rio de Janeiro (Brazil); 1-6 Oct 1989)			
	15:8098	*See* INIS-BR–1761			

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CONF-891052–		(Atomic processes in plasmas; Gaithersburg, MD (USA); 2-6 Oct 1989)			
1	15:8626	*See* LA-UR–89-3982			
CONF-891093–		(36. American Vacuum Society national vacuum symposium; Boston, MA (USA); 23-27 Oct 1989)			
16	15:8655	*See* BNL–43462			
CONF-891094–		(International conference on accelerator and large experimental physics control systems; Vancouver (Canada); 30 Oct - 3 nov 1989)			
7	15:8241	*See* BNL–43074			
8	15:8242	*See* BNL–43075			
9	15:8243	*See* BNL–43092			
10	15:8249	*See* LA-UR–89-3685			
CONF-891103–		(Winter meeting of the American Nuclear Society; San Francisco, CA (USA); 26-30 Nov 1989)			
52	15:7527	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003549	MF-530
53	15:7512	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003554	
55	15:7528	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003567	MF-530
57	15:7510	*See* PNL-SA–17057			
61	15:7577	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003778	MF-523
CONF-8911130–		(11. US/Japan workshop on field-reversed configurations and compact toroids; Los Alamos, NM (USA); 7-9 Nov 1989)			
3	15:8849	*See* LA-UR–89-3950			
4	15:8936	*See* LA-UR–89-3827			
6	15:8848	*See* LA-UR–89-3742			
CONF-8911133–		(Food processing waste conference; Atlanta, GA (USA); 6-8 Nov 1989)			
1	15:7834	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003572	MF-310
CONF-8911138–		(7. American Physical Society topical conference on atomic processes in plasmas; Gaithersburg, MD (USA); Nov 1989)			
1	15:8662	*See* LA-UR–89-4047			
CONF-8911140–		(1989 FORML conference; Pacific Grove, CA (USA); 24-26 Nov 1989)			
1	15:9011	*See* LA-UR–89-3679			
CONF-8911142–		(International symposium on self-assembly of organic compounds; Fukuoka (Japan); 6-9 Nov 1989)			
1	15:8133	*See* DOE/ER/13506–26			
CONF-8911146–		(Banbury Center conference on mutation induction and heritability in mammalian germ cells; Cold Spring Harbor, NY (USA); 12-15 Nov 1989)			
1	15:8532	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003715	MF-408
CONF-8911148–		(ASTM Subcommittee meeting; Orlando, FL (USA); 28-29 Nov 1989)			
1-Vugraphs	15:8584	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003707	MF-408
CONF-8911150–		(6. international conference on recent progress in many body theories; Arad (Israel); 6-10 Nov 1989)			
1	15:8779	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003558	MF-413
CONF-8911151–		(International conference on ocean energy recovery; Honolulu, HI (USA); 28-30 Nov 1989)			
1	15:7194	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003551	MF-262
CONF-8911152–		(10. HMCRI's national conference and exhibition; Washington, DC (USA); 27-29 Nov 1989)			
1	15:7041	*See* PNL-SA–17455			
CONF-891116–		(First international SAMPE symposium and exhibition on new materials and processes for the future; Chiba (Japan); 28 Nov - 1 dec 1989)			
2	15:8943	*See* PNL-SA–17297			
CONF-891117–		(34. conference on magnetism and magnetic materials; Boston, MA (USA); 28 Nov - 1 dec 1989)			
12	15:8062	*See* PNL-SA–17227			
CONF-891118–		(International meeting on nuclear criticality safety margins; San Francisco, CA (USA); 26 Nov - 1 dec 1989)			
10	15:7574	*See* PNL-SA–17248			

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CONF-891119–		(Materials Research Society fall meeting; Boston, MA (USA); 27 Nov - 2 dec 1989)			
18	15:7893	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003564	MF-404
30	15:8048	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003788	MF-404
34	15:8063	*See* SAND–89-1534C			
35	15:7998	*See* BNL–43576			
36	15:7996	*See* BNL–43068			
37	15:7995	*See* BNL–43006			
40	15:8064	*See* SAND–89-1822C			
41	15:8049	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004297	MF-404
CONF-891120–		(Migration '89: 2nd international conference on chemistry and migration behavior of actinides and fission products in the geosphere; Monterey, CA (USA); 6-10 Nov 1989)			
5	15:6978	*See* LA-UR–89-3733			
CONF-891131–		(Indirect liquefaction contractors review meeting; Pittsburgh, PA (USA); 13-15 Nov 1989)			
1	15:6678	*See* SAND–89-7146C			
CONF-891137–		(2. international symposium on superconductivity; Tsukuba (Japan); 14-17 Nov 1989)			
1	15:7997	*See* BNL–43137			
CONF-891192–		(Annual Westinghouse computer symposium; Pittsburgh, PA (USA); 6-7 Nov 1989)			
19	15:7565	*See* WSRC-RP–89-344			
21	15:6955	*See* WSRC-RP–89-480			
22	15:7597	*See* WSRC-RP–89-524			
23	15:7596	*See* WSRC-RP–89-345			
24	15:7923	*See* WSRC-RP–89-476			
CONF-891202–		(4. thermal performance of the exterior envelopes of buildings; Orlando, FL (USA); 4-7 Dec 1989)			
7	15:7779	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003719	MF-350
8	15:7780	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003720	MF-350
CONF-891204–		(4. international conference on fusion reactor materials; Kyoto (Japan); 4-8 Dec 1989)			
6	15:8801	*See* PNL-SA–16991			
7	15:8944	*See* PNL-SA–17480			
8	15:8942	*See* PNL-SA–17021			
9	15:8941	*See* PNL-SA–16980			
CONF-891208–		(Winter annual meeting of the American Society of Mechanical Engineers; San Francisco, CA (USA); 10-15 Dec 1989)			
26	15:9015	*See* SAND–89-1608C			
CONF-891210–		(9. Miami international congress on energy and environment; Miami Beach, FL (USA); 11-13 Dec 1989)			
1	15:7151	*See* SERI/TP–211-3604			
2	15:8403	*See* SAND–89-1338C			
CONF-891214–		(Hypervelocity impact symposium; San Antonio, TX (USA); 12-14 Dec 1989)			
14	15:8174	*See* SAND–89-0507C			
CONF-891260–		(International cosmic ray conference; Adelaide (Australia); 28 Dec 1989)			
1	15:8277	*See* DOE/ER/40039–32			
2	15:8615	*See* DOE/ER/40039–33			
3	15:8616	*See* DOE/ER/40039–34			
4	15:8278	*See* DOE/ER/40039–35			
5	15:8617	*See* DOE/ER/40039–36			
6	15:8618	*See* DOE/ER/40039–37			
7	15:8619	*See* DOE/ER/40039–38			
8	15:8620	*See* DOE/ER/40039–39			
CONF-900102–		(13. energy-sources technology conference and exhibition; New Orleans, LA (USA); 14-18 Jan 1990)			
1	15:8368	*See* UCRL–101156			
2	15:8050	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89015351	MF-404
CONF-900108–		(Reliability and maintainability symposium; Los Angeles, CA (USA); Jan 1990)			
1	15:9009	*See* LA-UR–89-1383			
2	15:9019	*See* SAND–89-2592C			

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CONF-900109–		(7. symposium on space nuclear power systems; Albuquerque, NM (USA); 7-11 Jan 1990)			
2	15:7549	*See* LA-UR–89-1952			
3	15:7550	*See* LA-UR–89-1982			
4	15:7554	*See* SAND–89-1635C			
5	15:7546	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89016221	MF-528
6	15:8349	*See* SAND–89-2277C			
7	15:7551	*See* LA-UR–89-2633			
9	15:8204	*See* SAND–89-2374C			
11	15:7552	*See* LA-UR–89-3363			
12	15:7547	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002274	MF-528
13	15:7548	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002276	MF-528
14	15:7553	*See* LA-UR–89-3365			
CONF-900116–		(International joint conference on neural networks; Washington, DC (USA); 15-19 Jan 1990)			
1	15:9016	*See* SAND–89-1916C			
2	15:9006	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89015974	MF-405
3	15:9007	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89015975	
CONF-900121–		(Transportation Research Board meeting; Washington, DC (USA); Jan 1990)			
1	15:7821	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89016259	
2	15:7822	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89016260	
3	15:6960	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90000704	MF-600
4	15:7823	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90001597	
CONF-900122–		(21. international cosmic ray conference; Adalaide (Australia); 6-19 Jan 1990)			
1	15:8623	*See* LA-UR–89-2971			
2	15:8339	*See* LA-UR–89-2970			
3	15:8624	*See* LA-UR–89-2989			
4	15:8631	*See* UCRL–101948			
5	15:8753	*See* LBL–27725			
CONF-900128–		(International conference on recrystallization in metallic materials; Wollongong (Australia); 22-26 Jan 1990)			
1	15:8803	*See* UCRL–100615			
2	15:8802	*See* UCRL–100614			
CONF-900129–		(21. international cosmic ray conference; Adelaide (Australia); 6-19 Jan 1990)			
1	15:3765	*See* LBL–27672			
2	15:8627	*See* LBL–27673			
3	15:8635	*See* UCRL–102240			
4	15:8636	*See* UCRL–102243			
5	15:8272	*See* ANL-HEP-CP–89-91			
CONF-900136–		(9. ASME wind energy symposium; New Orleans, LA (USA); 14-17 Jan 1990)			
1	15:7456	*See* SAND–89-2476C			
2	15:7457	*See* SAND–89-2597C			
3	15:7455	*See* SAND–89-1795C			
4	15:7454	*See* SAND–89-1536C			
5	15:7459	*See* SERI/TP–257-3558			
6	15:7460	*See* SERI/TP–257-3589			
CONF-900137–		(Hawaii international conference on systems sciences: massive databases and I11-defined objects; Kailua-Kona, HI (USA); 2-5 Jan 1990)			
1	15:9010	*See* LA-UR–89-3244			
CONF-900138–		(5. annual battery conference on applications and advances; Long Beach, CA (USA); 16-18 Jan 1990)			
1	15:7636	*See* SAND–89-2214C			
2	15:7637	*See* SAND–89-2312C			
3	15:7192	*See* SAND–89-2134C			
CONF-900139–		(8. international modal analysis conference; Kissimmee, FL (USA); 29 Jan - 1 feb 1990)			
1	15:8819	*See* LA-UR–89-3376			
2	15:8818	*See* LA-UR–89-3375			

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CONF-900140–		(SPIE optics, electro-optics and laser applications in science and engineering conference and exhibition; Los Angeles, CA (USA); 20-25 Jan 1990)			
1	15:7625	*See* SAND–89-2733C			
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5	15:8273	*See* BNL–43559			
CONF-900145–		(8. international modal analysis conference; Orlando, FL (USA); 29 Jan - 1 feb 1990)			
1	15:8162	*See* SAND–89-1729C			
CONF-900146–		(1990 DAZIX Users' Group meeting; San Francisco, CA (USA); 23-25 Jan 1990)			
1	15:9020	*See* SAND–89-2712			
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11666	15:6807	NTIS (US Sales Only), PC A03/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg; Price: ECU 5			
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11794	15:6808	NTIS (US Sales Only), PC A05/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg ECU 7.50			
11808	15:7105	NTIS (US Sales Only), PC A03/MF A01; Office for Official Publications of the Eruopean Communities, 2, rue Mercier, L-2985 Luxembourg			
11809	15:6958	NTIS (US Sales Only), PC A04/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg; Price: ECU 5			
12092	15:7082	NTIS (US Sales Only), PC A04/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg; Price: ECU 7,50			
12162	15:6847	NTIS (US Sales Only), PC A06/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg; Price: ECU 10			
12240	15:8096	NTIS (US Sales Only), PC A03/MF A01			

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
EUR–					
12271	15:7571	NTIS (US Sales Only), PC A06/MF A01			
8520	15:6950	NTIS (US Sales Only), PC A02/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg; Price: ECU 3.40			
9204	15:7688	NTIS (US Sales Only), PC A03/MF A01; Office for Official Publications of the European Communities, 2, rue Mercier, L-2985 Luxembourg			
EWE–					
2572-01	15:7585	NTIS (US Sales Only), PC A05/MF A01 - OSTI		DE90705962	
FDAL–					
P-362	15:7056	PC Petawawa National Forestry Institute, Distribution Centre, P.O. Box 2000, Chalk River, ON, CAN K0J 1J0; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN			
FFA-TN–					
1988-67	15:7462	*See* STEV-VIND–89-19			
FFAP-A–					
779	15:7430	*See* STEV-VIND–89-15			
FNAL-TM–					
1632	15:8279	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004998	PC-414
FNAL/C–					
89/237-T	15:8729	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003941	MF-412
FRNC-TH–					
3511	15:7448	NTIS (US Sales Only), PC A05		DE90708160	
FSU-SCRI–					
89-147	15:8729	*See* FNAL/C–89/237-T			
FhG-IWM-W–					
7/89	15:8054	NTIS (US Sales Only), PC A03/MF A01		DE90728816	
GA-A–					
19743	15:8928	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004097	MF-426
19745	15:8929	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004096	MF-420
19759	15:8930	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004099	MF-426
19760	15:8931	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004098	MF-420
19794	15:8834	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004103	MF-421
19803	15:8835	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003942	MF-420
GAO/RCED–					
89-116	15:7881	US General Accounting Office, PO Box 6015, Gaithersburg, MD 20877			
89-134BR	15:7572	US General Accounting Office, PO Box 6015, Gaithersburg, MD 20877			
89-153	15:6657	US General Accounting Office, PO Box 6015, Gaithersburg, MD 20877			
89-170BR	15:6953	US General Accounting Office, PO Box 6015, Gaithersburg, MD 20877			
GKSS–					
88/E/71	15:7900	Available from GKSS-Forschungszentrum Geesthacht GmbH, Geesthacht-Tesperhude (Germany, F.R.)			
88/E/72	15:7901	Available from GKSS-Forschungszentrum Geesthacht GmbH, Geesthacht-Tesperhude (Germany, F.R.)			
89/E/24	15:8393	Available from GKSS-Forschungszentrum Geesthacht GmbH, Geesthacht-Tesperhude (Germany, F.R.)			
GKYA–					
7218DD71	15:8184	PC Canada Mortgage and Housing Corporation, Annex Bldg., 628 Montreal Rd., Ottawa, ON, CAN K1A 0P7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN			
GS–					
89-1G	15:8604	PC Canadian Government Publishing Centre, Supply and Services Canada, Ottawa, ON, CAN K1A 0S9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN			

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
GSF-					
1/89	15:6972	NTIS (US Sales Only), PC A06/MF A01		DE90732391	
25/88	15:6973	NTIS (US Sales Only), PC A11/MF A01		DE90732324	
GSF-K-					
74	15:7703	NTIS (US Sales Only), PC A03/MF A01		DE90732347	
GSI-					
89-11	15:8097	NTIS (US Sales Only), PC A06/MF A01		DE90728609	
89-65(prepr.)	15:8751	Available from Gesellschaft fuer Schwerionen-forschung m.b.H., Darmstadt (Germany, F.R.)			
GSJ-					
8901	15:7357	NTIS (US Sales Only), PC A13/MF A01		DE89910150	
GWI-					
7610	15:6929	NTIS (US Sales Only), PC A13/MF A01		DE90732394	
HCR-CDTN-					
09	15:8558	NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS		DE90612177	
HQ-					
89-03178	15:7747	PC Hydro-Quebec, Centre de diffusion, 75, boul. Dorchester ouest, 14e etage, Montreal, PQ, CAN H2Z 1A4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN			
89-04543	15:7463	PC Hydro-Quebec, Centre de diffusion, 75, boul. Dorchester ouest, 14e etage, Montreal, PQ, CAN H2Z 1A4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN			
89-05086	15:7464	PC Hydro-Quebec, Centre de diffusion, 75, boul. Dorchester ouest, 14e etage, Montreal, PQ, CAN H2Z 1A4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN			
IAEA-INFCIRC-					
370	15:9001	NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS		DE90612718	
IBP-WB-					
7/87	15:7786	Copy held by UB/TIB Hannover			
9/87	15:7787	NTIS (US Sales Only), PC A03/MF A01		DE90732471	
IC-					
89/282	15:8730	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90003441	
89/81	15:8609	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90610795	
IEE-SR-					
205	15:7645	NTIS (US Sales Only), PC A06/MF A01		DE89910215	
206	15:7646	NTIS (US Sales Only), PC A09/MF A01		DE89910216	
207	15:7668	NTIS (US Sales Only), PC A09/MF A01		DE89910213	
IEEJ-					
8901	15:7824	NTIS (US Sales Only), PC A12/MF A01		DE89910080	
8902	15:7610	NTIS (US Sales Only), PC A15/MF A01		DE89910081	
8903	15:7602	NTIS (US Sales Only), PC A12/MF A01		DE89910083	
IKE-					
2-82	15:7529	NTIS (US Sales Only), PC A07/MF A01		DE90732509	
ILWRP-					
86/P9	15:6959	*See* AERE-R-12774			
87-P15	15:8090	*See* AERE-R-13137			
89-P02	15:6966	*See* DOE-RW-89.050			
INDC-EUR-					
022-G	15:8796	*See* NEANDC(E)-292-U-Vol.III-Euratom			
INFN-LNF-					
89-035(P)	15:8233	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90610937	
89-21(P)	15:8232	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90610938	
INIS-BR-					
1761	15:8098	NTIS (US Sales Only), PC A03/MF A01 - OSTI		DE90610739	
INIS-SU-					
132/A	15:8775	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90610728	

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
133/A	15:7883	NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS		DE90705983	
INIS-mf–					
11516	15:8932	NTIS (US Sales Only), PC A06/MF A01 - OSTI		DE90705961	
11517	15:8836	NTIS (US Sales Only), PC A09/MF A01 - OSTI		DE90705960	
11518	15:7567	NTIS (US Sales Only), PC A08/MF A01 - OSTI		DE90705959	
11519	15:8657	NTIS (US Sales Only), PC A06/MF A01 - OSTI		DE90705958	
11521	15:7902	NTIS (US Sales Only), PC A07/MF A01 - OSTI		DE90705957	
11523	15:8731	NTIS (US Sales Only), PC A07/MF A01 - OSTI		DE90705972	
11525	15:8552	NTIS (US Sales Only), PC A06/MF A01 - OSTI		DE90705971	
11560	15:8997	NTIS (US Sales Only), PC A07/MF A01 - OSTI; INIS		DE90608904	
11571	15:8621	NTIS (US Sales Only), PC A09/MF A01 - OSTI; INIS		DE90611419	
11572	15:8622	NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS		DE90611424	
12023	15:8089	NTIS (US Sales Only), PC A14/MF A01		DE90732327	
12024	15:7519	NTIS (US Sales Only), PC A10/MF A01		DE90732342	
12025	15:8440	NTIS (US Sales Only), PC A04/MF A01		DE90732340	
12026	15:6848	NTIS (US Sales Only), PC A09/MF A01		DE90732341	
12027	15:6974	NTIS (US Sales Only), PC A09/MF A01		DE90732323	
12028	15:6975	NTIS (US Sales Only), PC A03/MF A01		DE90732322	
12029	15:7515	NTIS (US Sales Only), PC A06/MF A01		DE90732321	
12030	15:8441	NTIS (US Sales Only), PC A03/MF A01		DE90732306	
12031	15:7586	NTIS (US Sales Only), PC A03/MF A01		DE90732343	
12032	15:7587	NTIS (US Sales Only), PC A06/MF A01		DE90732505	
12033	15:7748	NTIS (US Sales Only), PC A08/MF A01		DE90729204	
12034	15:7234	NTIS (US Sales Only), PC A02/MF A01		DE90732393	
12035	15:8171	NTIS (US Sales Only), PC A03/MF A01		DE90732413	
12036	15:8056	NTIS (US Sales Only), PC A04/MF A01		DE90732381	
12037	15:7520	NTIS (US Sales Only), PC A03/MF A01		DE90732698	
12038	15:7521	NTIS (US Sales Only), PC A06/MF A01		DE90732697	
12039	15:7522	NTIS (US Sales Only), PC A03/MF A01		DE90732696	
12040	15:8535	NTIS (US Sales Only), PC A07/MF A01		DE90732614	
12041	15:8536	NTIS (US Sales Only), PC A03/MF A01		DE90732610	
12042	15:8537	NTIS (US Sales Only), PC A03/MF A01		DE90732609	
12043	15:8560	NTIS (US Sales Only), PC A06/MF A01		DE90732604	
12044	15:8561	NTIS (US Sales Only), PC A06/MF A01		DE90732603	
12045	15:8538	NTIS (US Sales Only), PC A07/MF A01		DE90732602	
12046	15:8539	NTIS (US Sales Only), PC A04/MF A01		DE90732601	
INP–					
1318/PS	15:8658	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90610543	
1326/B	15:7704	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90610984	
1331/B	15:8540	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90610924	
INS–					
753	15:8659	NTIS (US Sales Only), PC A03/MF A01		DE90733098	
INS-R–					
332	15:9002	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90612728	
340	15:8554	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90612254	
345	15:7358	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90612070	
346	15:7044	NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS		DE90612435	
352	15:8442	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90612084	
358	15:8562	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90612179	
IPP–					
6/254	15:8815	NTIS (US Sales Only), PC A03/MF A01		DE90729143	
IRI–					
1987	15:7558	NTIS (US Sales Only), PC A09/MF A01 - OSTI		DE90705955	
1988	15:7559	NTIS (US Sales Only), PC A04/MF A01 - OSTI		DE90705954	
1989	15:7560	NTIS (US Sales Only), PC A04/MF A01 - OSTI		DE90705953	
ISPO–					
308	15:7043	*See* K/ITP–304			

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
IT–					
CE-02785	15:6909	Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $35.00 CAN			
CE-02787	15:6885	Info-Tech (Div. Of Maclean Hunter Ltd.), Suite 200, 1015 Centre Street North, Calgary, AB, CAN T2E 2P8. Prices: $65.00 CAN			
ITF–					
88-70	15:8720	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611035	
ITFA–					
88-53	15:8816	NTIS (US Sales Only), PC A03/MF A01 - OSTI		DE90705952	
ITP–					
88-57	15:8837	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611306	
88-58	15:8838	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611307	
88-66	15:8839	NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS		DE90611308	
88-71	15:8840	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611309	
IYaF–					
88-113	15:8732	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611018	
88-125	15:8733	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611019	
88-136	15:8817	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90610995	
88-165	15:8841	NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS		DE90611310	
89-48	15:8842	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611281	
JAERI-M–					
89-095	15:7564	NTIS (US Sales Only), PC A08/MF A01		DE90733141	
89-098	15:6954	NTIS (US Sales Only), PC A03/MF A01		DE90733139	
89-099	15:7573	NTIS (US Sales Only), PC A03/MF A01		DE90733143	
89-101	15:8167	NTIS (US Sales Only), PC A03/MF A01		DE90733142	
89-103	15:8843	NTIS (US Sales Only), PC A03/MF A01		DE90733144	
89-104	15:8844	NTIS (US Sales Only), PC A03/MF A01		DE90733140	
89-105	15:8933	NTIS (US Sales Only), PC A03/MF A01		DE90733145	
89-106	15:8845	NTIS (US Sales Only), PC A04/MF A01		DE90733146	
89-115	15:8934	NTIS (US Sales Only), PC A03/MF A01		DE90733138	
JET-R–					
89-04	15:8846	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611269	
89-10	15:8847	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611183	
JINR-D–					
1-13-88-172	15:8689	NTIS (US Sales Only), PC A18/MF A01 - OSTI; INIS		DE90705987	
JINR-E–					
9-89-491	15:8265	NTIS (US Sales Only), PC A02/MF A01; OSTI; Joint Institute for Nuclear Research, Publishing Department, Head Post Office, P.O. Box 79 101000, Moscow, USSR		DE90004315	
Juel–					
1986	15:8660	NTIS (US Sales Only), PC A03/MF A01		DE90732694	
2230	15:7523	NTIS (US Sales Only), PC A07/MF A01		DE90732348	
2241	15:7741	NTIS (US Sales Only), PC A04/MF A01		DE90732478	
2260	15:8563	NTIS (US Sales Only), PC A03/MF A01		DE90732331	
2265	15:8445	NTIS (US Sales Only), PC A06/MF A01		DE90732330	
2274	15:7914	NTIS (US Sales Only), PC A06/MF A01		DE90732691	
2280	15:8935	NTIS (US Sales Only), PC A03/MF A01		DE90732692	
2290	15:8395	NTIS (US Sales Only), PC A08/MF A01		DE90732539	
2307	15:6832	NTIS (US Sales Only), PC A13/MF A01		DE90732538	
Juel-Spez–					
451	15:8355	NTIS (US Sales Only), PC A04/MF A01		DE90732320	
508	15:7714	NTIS (US Sales Only), PC A03/MF A01		DE90729027	
512	15:8158	NTIS (US Sales Only), PC A10/MF A01		DE90732540	
513	15:8000	NTIS (US Sales Only), PC A05/MF A01		DE90732583	
514(v.2)	15:7524	NTIS (US Sales Only), PC A07/MF A01		DE90732553	

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K/ITP–					
304	15:7043	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003516	MF-515
KFA-ASS–					
0493	15:8599	NTIS (US Sales Only), PC A11/MF A01		DE90732545	
KFK–					
4288	15:7915	NTIS (US Sales Only), PC A04/MF A01		DE90728838	
4297	15:7916	NTIS (US Sales Only), PC A03/MF A01		DE90732693	
4414	15:8057	NTIS (US Sales Only), PC A06/MF A01		DE90732695	
4583	15:8001	NTIS (US Sales Only), PC A08/MF A01		DE90732508	
4600	15:7861	NTIS (US Sales Only), PC A04/MF A01		DE90729010	
KFKI–					
1989-27/A	15:8702	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611469	
1989-32/A	15:8734	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611021	
KIYI–					
88-16	15:8247	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90612488	
88-41	15:8248	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90612503	
KVM–					
19	15:8586	NTIS (US Sales Only), PC A03/MF A01		DE90728270	
21	15:8396	NTIS (US Sales Only), PC A03/MF A01		DE90728269	
LA–					
11103-MS	15:7359	NTIS, PC A04/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003433	
11522-MS	15:7917	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004423	PC-700
11541-MS	15:8427	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003989	PC-702
11691-MS	15:6976	NTIS, PC A07/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003988	PC-814
11694-MS	15:6977	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004424	MF-802
11711-M	15:8752	NTIS, PC A13/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004990	MF-705
LA-UR–					
89-1383	15:9009	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89012610	MF-700
89-1952	15:7549	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89014817	MF-528
89-1982	15:7550	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89014561	MF-743
89-2633	15:7551	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90000612	MF-520; MF-506
89-2970	15:8339	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE89016781	MF-412
89-2971	15:8623	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE89016780	MF-412
89-2989	15:8624	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90000609	MF-406; MF-412
89-3244	15:9010	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90000686	MF-905
89-3363	15:7552	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002430	MF-528
89-3365	15:7553	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002655	MF-528
89-3375	15:8818	NTIS, PC A02/MF A01; OSTI; INIS		DE90002395	MF-910
89-3376	15:8819	NTIS, PC A02/MF A01; OSTI; INIS		DE90002394	MF-910
89-3440-Exc.	15:7679	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003363	MF-700
89-3679	15:9011	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003393	MF-705
89-3685	15:8249	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003391	MF-414; MF-405
89-3733	15:6978	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003191	MF-814
89-3742	15:8848	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003397	MF-426
89-3769	15:8661	NTIS, PC A03/MF A01 - OSTI		DE90003394	MF-700; MF-705
89-3788	15:8625	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003215	MF-910
89-3827	15:8936	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003218	MF-700
89-3946	15:8937	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003657	MF-700
89-3950	15:8849	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003656	MF-427
89-3982	15:8626	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003654	MF-700
89-4026	15:8703	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003223	MF-412
89-4047	15:8662	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003221	MF-700
LBL–					
25457	15:8002	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004247	MF-404
26675	15:8250	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003997	MF-414
27475	15:8735	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004034	MF-414
27598	15:7237	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002119	MF-251
27654	15:8767	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004027	MF-413
27672	15:8765	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90000134	MF-410
27673	15:8627	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90000132	MF-411
27725	15:8753	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90002683	MF-412
27856	15:8691	*See* SLAC–353			
27859	15:7669	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003992	MF-500

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
27879	15:8610	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003938	MF-403
27886	15:8058	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004028	MF-404
27926	15:8773	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004033	MF-414
27954	15:7486	NTIS, PC A06/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004026	MF-111
27955	15:7046	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003937	MF-109
27956	15:6755	NTIS, PC A09/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003991	MF-106
27983	15:8780	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004032	MF-413
28058	15:7754	NTIS, PC A05/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003996	MF-350
LMOSC–					
89-03677	15:8397	PC British Columbia Legislative Library, Government Documents Division, Parliament Buildings, Victoria, BC, CAN V8V 1X4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN			
LUMEDW-MEFL–					
1006-5-179-1989	15:8541	NTIS (US Sales Only), PC A09/MF A01 - OSTI; INIS		DE90610919	
LUTKDH-TKKT–					
1005-1-84	15:8149	*See* STEV-FBT–89-40			
MBB-UE–					
0001-89-PUB	15:7449	Copy held by UB/TIB Hannover			
MEA–					
2364	15:7563	*See* NUREG/CR–5469			
MEM/P–					
89-05719	15:6868	PC Manitoba Energy and Mines., Information Centre, 555-330 Graham Ave., Winnipeg, MB, CAN R3C 4E3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN			
MHD-ITC–					
89-285	15:7769	*See* DOE/PC/90274–T7			
MICROLOG–					
88-06463	15:7410	*See* CANWEA–88-06463			
89-02410	15:7687	*See* EMR/MR–85-66TR			
89-03178	15:7747	*See* HQ–89-03178			
89-03293	15:8604	*See* GS–89-1G			
89-03664	15:8183	*See* CPS–40-11/14-1989E			
89-03677	15:8397	*See* LMOSC–89-03677			
89-03682	15:6916	*See* BCUC–89-03683			
89-03683	15:6915	*See* BCUC–89-03683			
89-03684	15:6917	*See* BCUC–89-03684			
89-03687	15:8205	*See* SCBC–89-03687			
89-03699	15:7829	*See* AC/CB–1799/E			
89-03724	15:7681	*See* RFW–87-03724			
89-03756	15:7509	*See* SRC–E-906-14-D-86			
89-03823	15:7111	*See* BCH/RP–89-03823			
89-03824	15:7756	*See* OH/EF–881212			
89-03895	15:6870	*See* BES–89-03895			
89-03925	15:6882	*See* NTRR–89-03925			
89-04003	15:6892	*See* NDA–88-063			
89-04022	15:6778	*See* BCR–TP8334E			
89-04033	15:7870	*See* AIL–TP8307E			
89-04040	15:7868	*See* BI/RDPD–TP9022E			
89-04067	15:7867	*See* BI/RDPD–TP8395E			
89-04146	15:7680	*See* NBMAE–89-04146			
89-04147	15:6823	*See* NBNRE–89-6			
89-04176	15:7743	*See* BCH/RP–89-04176			
89-04192	15:6919	*See* CRPC–89-04192			
89-04270	15:7774	*See* AIRINS–89-04270			
89-04275	15:7803	*See* NRC/IRC–CR55051			
89-04277	15:7205	*See* S–89-04277			
89-04298	15:7617	*See* OH/RD–89-26-K			
89-04301	15:7624	*See* OH/RD–89-45-K			
89-04302	15:7618	*See* OH/RD–89-38-K			
89-04304	15:7492	*See* OH/RD–88-326-K			
89-04306	15:7623	*See* OH/RD–88-270-K			
89-04308	15:7616	*See* OH/RD–89-11K			
89-04316	15:7614	*See* OH/RD–88-271-K			

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
89-04317	15:8060	*See* OH/RD–88-251-K			
89-04320	15:7611	*See* OH/RD–88-161-K			
89-04333	15:8184	*See* GKYA–7218DD71			
89-04402	15:7196	*See* CMHC–87E53			
89-04410	15:7775	*See* AIRINS–89-04410			
89-04430	15:7491	*See* OH/RD–88-292-K			
89-04431	15:7490	*See* OH/RD–88-199-K			
89-04432	15:7108	*See* OH/RD–88-327-K			
89-04433	15:7507	*See* OH/RD–88-329-K			
89-04436	15:7613	*See* OH/RD–88-231-K			
89-04437	15:8464	*See* OH/RD–88-185-K			
89-04440	15:7110	*See* OH/RD–88-281-K			
89-04441	15:8185	*See* OH/RD–88-213-K			
89-04448	15:6757	*See* OH/RD–88-305-K			
89-04450	15:7113	*See* OH/RD–88-103-K			
89-04484	15:8186	*See* RPC–MDP/88/17			
89-04514	15:7056	*See* FDAL–P-362			
89-04515	15:7101	*See* NA–P-363			
89-04543	15:7463	*See* HQ–89-04543			
89-04559	15:7804	*See* OH/RD–88-219-K			
89-04560	15:7628	*See* OH/RD–88-239-K			
89-04568	15:8430	*See* OH/RD–88-296-K			
89-04569	15:8431	*See* OH/RD–89-30-K			
89-04572	15:8061	*See* OH/RD–99-320-K			
89-04579	15:7622	*See* OH/RD–88-183-K			
89-04582	15:7615	*See* OH/RD–88-304-K			
89-04585	15:7612	*See* OH/RD–88-216-K			
89-04587	15:7109	*See* OH/RD–88-323-K			
89-04589	15:8091	*See* CANMET–84-54TR			
89-04608	15:7897	*See* EMR/CANMET–PMRL85-71(TR)			
89-04675	15:8059	*See* OH/RD–88-196-K			
89-04747	15:7805	*See* OH/RD–MSDD87-13			
89-04905	15:7740	*See* COGLA–89-04905			
89-04918	15:7738	*See* AE/P–89-04918			
89-05085	15:7698	*See* EC/CPG–89-05085E			
89-05085	15:7699	*See* EC/CPG–89-05085F			
89-05086	15:7464	*See* HQ–89-05086			
89-05163	15:7718	*See* AFLW–89-05163			
89-05523	15:7730	*See* OEB–89-05523			
89-05719	15:6868	*See* MEM/P–89-05719			
89-05821	15:6862	*See* AMPC–89-05821			
MLM–					
3609	15:8364	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002639	PC-706
MLWIA–					
CE-02808	15:7802	CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: $0.34 CAN per page, $3.40 minimum			
MMS–					
90003668	15:7689	OSTI; Mineral Management Service, P.O. Box 101159, Anchorage, AK 99510		TI90003668	
MSHA/IR–					
1163	15:8356	NTIS, PC A02/MF A01 - OSTI		DE90003743	
1168	15:8193	NTIS, PC A06/MF A01 - OSTI		DE90003741	
1192	15:8194	NTIS, PC A06/MF A01 - OSTI		DE90003733	
90003748	15:8195	NTIS, PC A08/MF A01 - OSTI		DE90003748	
90003750	15:8196	NTIS, PC A05/MF A01 - OSTI		DE90003750	
NA–					
P-363	15:7101	PC Petawawa National Forestry Institute, Distribution Centre, P.O. Box 2000, Chalk River, ON, CAN K0J 1J0; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN			
NAI-SR–					
101	15:7033	*See* WSRC-RP–89-1059			
97	15:8478	*See* WSRC-RP–89-1058			
NAL-TR–					
1001	15:6896	NTIS (US Sales Only), PC A03/MF A01		DE89910193	
975T	15:7488	NTIS (US Sales Only), PC A03/MF A01		DE89910183	
981	15:8159	NTIS (US Sales Only), PC A03/MF A01		DE89910142	

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985T	15:7489	NTIS (US Sales Only), PC A03/MF A01		DE89910185	
992	15:7202	NTIS (US Sales Only), PC A03/MF A01		DE89910187	
994	15:7149	NTIS (US Sales Only), PC A03/MF A01		DE89910140	
998	15:7826	NTIS (US Sales Only), PC A03/MF A01		DE89910189	
NBMAE–					
89-04146	15:7680	PC New Brunswick Electric Power Commission, 515 King St., Fredericton, NB, CAN E3B 4X1; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN			
NBNRE–					
89-6	15:6823	PC New Brunswick Dept. of Natural Resources and Energy, P.O. Box 6000, Fredericton, NB, CAN E3B 5H1; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $2.00 CAN; MF $10 CAN			
NBU/ME–					
180D579	15:7621	Canadian Electrical Association, Research & Development, Suite 500, One Westmount Square, Montreal, PQ, CAN H3Z 2P9. Prices: $75.00 NON-MEMBERS; MEMBERS: PRICES UPON REQUEST FUNDS CAN			
NDA–					
88-063	15:6892	PC Nova Scotia Dept. of Mines and Energy, 1701 Hollis St., PO Box 1087, Halifax, NS, CAN B3J 2X1; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $3.00 CAN; MF $10 CAN			
NEA-CRP-L–					
302(Rev.)	15:8776	NTIS (US Sales Only), PC A17/MF A01 - OSTI; INIS		DE90610729	
NEANDC(E)–					
292-U-Vol.III-Euratom	15:8796	NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS		DE90610931	
NEANDC–					
245-U	15:8776	*See* NEA-CRP-L–302(Rev.)			
NEB-SS–					
EH-2-89	15:7755	National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: PRICES UPON REQUEST			
GH-4-88	15:6923	National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: N/C			
GH-4-88F	15:6924	National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: N/C			
GHW-1-89-E	15:6925	National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: N/C			
GHW-1-89-F	15:6926	National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: N/C			
RH-2-88	15:6927	National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: N/C			
RH-2-88-F	15:7729	National Energy Board, Trebla Bldg., 473 Albert St., Ottawa, ON, CAN K1A 0E5. Prices: N/C			
NEDOJ-P–					
8731	15:7451	NTIS (US Sales Only), PC A11/MF A01		DE89910386	
NEI-DK–					
226	15:6756	NTIS (US Sales Only), PC A08/MF A01		DE90728077	
231	15:8398	NTIS (US Sales Only), PC A07/MF A01		DE90728078	
232	15:7429	NTIS (US Sales Only), PC A05/MF A01		DE90728079	
234	15:7873	NTIS (US Sales Only), PC A05/MF A01		DE90728102	
235	15:7827	NTIS (US Sales Only), PC A09/MF A01		DE90728107	
236	15:6809	NTIS (US Sales Only), PC A15/MF A01		DE90728080	
237	15:7837	NTIS (US Sales Only), PC A06/MF A01		DE90728130	
238	15:7838	NTIS (US Sales Only), PC A05/MF A01		DE90728131	
239	15:7203	NTIS (US Sales Only), PC A03/MF A01		DE90728142	
240	15:6731	NTIS (US Sales Only), PC A05/MF A01		DE90728153	
241	15:7635	NTIS (US Sales Only), PC A05/MF A01		DE90728154	
242	15:7204	NTIS (US Sales Only), PC A06/MF A01		DE90728163	

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NEI-NO–					
100	15:6828	NTIS (US Sales Only), PC A12/MF A01		DE90728220	
72	15:6869	NTIS (US Sales Only), PC A07/MF A01		DE90728218	
NEI-SE–					
39	15:8428	NTIS (US Sales Only), PC A03		DE90705986	
NHL–					
284053	15:8463	NTIS (US Sales Only), PC A14/MF A01		DE90728248	
NIKHEF-H–					
89-7	15:8736	NTIS (US Sales Only), PC A03/MF A01 - OSTI		DE90705951	
89-9	15:8690	NTIS (US Sales Only), PC A03/MF A01 - OSTI		DE90705950	
NIKHEF-K-APS–					
88-03	15:8266	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90705949	
88-04	15:8267	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90705948	
NIKHEF-K-DIGEL–					
73	15:8251	NTIS (US Sales Only), PC A03/MF A01 - OSTI		DE90705969	
78	15:8268	NTIS (US Sales Only), PC A03/MF A01 - OSTI		DE90705947	
79	15:8252	NTIS (US Sales Only), PC A03/MF A01 - OSTI		DE90705968	
NIKHEF-K-IT–					
89-01	15:8269	NTIS (US Sales Only), PC A03/MF A01 - OSTI		DE90705967	
NIKHEF-K-LINO–					
138	15:8224	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90705946	
145	15:8225	NTIS (US Sales Only), PC A03/MF A01 - OSTI		DE90705945	
1989-3	15:8253	NTIS (US Sales Only), PC A03/MF A01 - OSTI		DE90705966	
NIKHEF-K-MTG–					
1989-1	15:8270	NTIS (US Sales Only), PC A03/MF A01 - OSTI		DE90705944	
NIPER–					
431	15:6851	NTIS, PC A04/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90000205	PC-122
432	15:6852	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90000202	PC-122
442	15:6853	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90000204	PC-122
447	15:6854	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90000203	PC-122
NRC/IRC–					
CR55051	15:7803	PC Environment Canada. Environmental Protection Publications, 10 Wellington St., 12th PVM, Ottawa, ON, CAN K1A 0H3; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN			
NTRR–					
89-03925	15:6882	PC Northwest Territories. Dept. of Renewable Resources, P.O. Box 1320, Yellowknife, NT, CAN X1A 2L9; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN			
NUREG–					
0020-Vol.13-No.9	15:7556	NTIS, PC A22/MF A01 - GPO; OSTI; INIS		TI90003612	
0090-Vol.12-No.2	15:7588	NTIS, PC A03/MF A01 - GPO - OSTI		TI90003029	
1380	15:6980	NTIS, PC A04/MF A01; OSTI; INIS		TI90003945	
NUREG/CR–					
2000-Vol.8-No.10	15:7557	NTIS, PC A06/MF A01 - GPO - OSTI		TI90004035	
5408	15:7918	NTIS, PC A07/MF A01 - GPO; OSTI; INIS		TI90004248	
5469	15:7563	NTIS, PC A10/MF A01 - GPO; OSTI; INIS		TI90003284	
NVR–					
2-3	15:7589	NTIS (US Sales Only), PC A03/MF A01 - OSTI		DE90705943	
OE–					
CE-02818	15:7862	Publications Ontario, 880 Bay St., 5th Floor, Toronto, ON, CAN M7A 1N8. Prices: N/C			
OEB–					
89-05523	15:7730	PC Ontario Energy Board, 14 Carlton St., 9th Floor, Toronto, Ont., CAN M5B 1J2; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC N/C; MF $10 CAN			
OG–					
1094	15:8273	*See* BNL–43559			

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OH/EF–					
881212	15:7756	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN			
OH/RD–					
712G619	15:6758	Canadian Electrical Association, Research & Development, Suite No. 500, One Westmount Square, Montreal, PQ, CAN H3Z 2P9. Prices: $75.00 NON-MEMBERS; MEMBERS: PRICES UPON REQUEST, FUNDS CAN			
717G620	15:7508	Canadian Electrical Association, Research & Development, Suite No. 500, One Westmount Square, Montreal, PQ, CAN H3Z 2P9. Prices: $75.00 NON-MEMBERS; MEMBERS: PRICES UPON REQUEST, FUNDS CAN			
88-103-K	15:7113	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-161-K	15:7611	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-183-K	15:7622	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-185-K	15:8464	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-196-K	15:8059	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-199-K	15:7490	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-213-K	15:8185	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-216-K	15:7612	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			

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88-219-K	15:7804	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-231-K	15:7613	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-239-K	15:7628	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-251-K	15:8060	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-270-K	15:7623	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-271-K	15:7614	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-281-K	15:7110	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-292-K	15:7491	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-296-K	15:8430	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-304-K	15:7615	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-305-K	15:6757	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-323-K	15:7109	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
88-326-K	15:7492	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-327-K	15:7108	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
88-329-K	15:7507	PC Experimental Datasearch Division, Computer Calculations, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
89-11K	15:7616	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
89-26-K	15:7617	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
89-30-K	15:8431	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
89-38-K	15:7618	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
89-45-K	15:7624	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
99-320-K	15:8061	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
MSDD87-13	15:7805	PC Ontario Hydro Research Division, Records Clerk, Bldg. KR 107, 800 Kipling Ave., Etobicoke, ON, CAN M8Z 5S4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC $10.00 CAN; MF $10 CAN			
ORF/ES–					
CE-02802	15:7806	Canada Mortgage and Housing Corporation, Annex Bldg., 628 Montreal Rd., Ottawa, ON, CAN K1A 0P7. Prices: PRICES UPON REQUEST			
ORNL–					
6526/R9	15:8432	NTIS, PC A06/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004402	MF-630
6536	15:8399	NTIS, PC A04/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004403	MF-721
6552	15:8400	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004404	MF-402
6557	15:6981	NTIS, PC A07/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004405	MF-811

ORNL–

Report Number	*Abstract Number*	*Source of Availability*	*GPO Dep.*	*Order Number*	*Distribution Category*
6558	15:8549	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004406	
6593	15:8340	NTIS, PC A10/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004408	MF-407
ORNL/ATD–					
23	15:8938	NTIS, PC A06/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004401	MF-404
ORNL/CON–					
290	15:7731	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004410	MF-920
ORNL/CSD/TM–					
265	15:9012	NTIS, PC A03/MF A01; OSTI; Order software packages from National Energy Software Center, Argonne National Laboratory, 9800 South Cass Avenue, Argonne, IL 60439. Order documentation without complete package from NTIS.; GPO Dep.	E 1.99:	DE90004409	MF-405
ORNL/EIS–					
154/V10	15:7038	NTIS, PC A17/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003943	MF-511
ORNL/FTR–					
2901	15:6982	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003983	MF-721
3423	15:8172	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003947	MF-400
3427	15:7590	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003946	MF-400
3463	15:7619	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003201	MF-400; MF-406
3471	15:7652	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003386	MF-350
3477	15:7525	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003994	
3479	15:8754	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003593	MF-413
3486	15:8401	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003591	MF-402
3487	15:7112	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003971	MF-400
3490	15:7878	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003517	MF-334
3491	15:8254	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003979	MF-414
ORNL/M–					
975-Vol.1	15:8587	NTIS, PC A99/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003931	
975-Vol.2	15:8588	NTIS, PC A99/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003932	
975-Vol.4	15:8589	NTIS, PC A99/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003934	
978	15:7058	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004412	MF-247
ORNL/NSIC–					
200-Vol.8-No.10	15:7557	*See* NUREG/CR–2000-Vol.8-No.10			
ORNL/RASA–					
87/29	15:8433	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004250	MF-511
87/30	15:8434	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004249	MF-511
87/31	15:8435	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003986	MF-511
87/34	15:8436	NTIS, PC A08/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004251	MF-511
89/11	15:8438	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004023	MF-511
89/6	15:8437	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003981	MF-511
ORNL/Sub–					
84-47989/4	15:7807	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003985	MF-350
85-22005/1	15:7620	NTIS, PC A07/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004370	MF-221
88-SC011/1	15:7084	NTIS, PC A05/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004416	MF-245
ORNL/TM–					
10265	15:8465	NTIS, PC A05/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004397	MF-600
10373	15:8016	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004379	PC-310
10416	15:7591	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004378	PC-610
10650	15:7568	NTIS, PC A05/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004375	PC-505
10823	15:9013	NTIS, PC A07/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004398	MF-405
10931	15:8173	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004400	MF-365
10992	15:6983	NTIS, PC A11/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004399	MF-721
11061	15:8466	NTIS, PC A04/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004359	MF-602
11084	15:8439	NTIS, PC A04/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004349	MF-721
11092	15:8370	NTIS, PC A06/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004360	MF-407
11093	15:8371	NTIS, PC A06/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004361	MF-407
11094	15:8372	NTIS, PC A07/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004362	MF-407
11095	15:8373	NTIS, PC A06/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004363	MF-407
11096	15:8374	NTIS, PC A06/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004364	MF-407
11097	15:8375	NTIS, PC A06/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004365	MF-407
11098	15:8376	NTIS, PC A06/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004366	MF-407
11099	15:8377	NTIS, PC A06/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004394	MF-407
11100	15:7863	NTIS, PC A11/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004350	
11193	15:8365	NTIS, PC A05/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004353	MF-700
11201	15:8363	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004354	
11254	15:8939	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004380	PC-426
11255	15:8940	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004381	PC-426
11261	15:9027	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004374	PC-722
11269	15:7918	*See* NUREG/CR–5408			

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
11278	15:7828	NTIS, PC A08/MF A01 - OSTI		DE90004356	
11281	15:7919	NTIS, PC A13/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004371	PC-404
11303	15:8402	NTIS, PC A06/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004396	MF-510
11304	15:8542	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004395	MF-408
11326	15:8160	NTIS, PC A04/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004392	
11336	15:9028	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004385	MF-405
11345	15:6759	NTIS, PC A04/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004386	MF-106; MF-110; MF-105
11355	15:6883	NTIS, PC A04/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004387	MF-510
11364	15:6984	NTIS, PC A07/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004369	PC-403
11370	15:8099	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004388	MF-404
11372	15:8781	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004389	MF-413
11373	15:9029	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004373	PC-722
11375	15:9014	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004390	MF-405
11377	15:8543	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004434	MF-408
11379	15:6812	NTIS, PC A07/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004391	
11401	15:7879	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003306	MF-334
11404	15:8766	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004393	MF-413
PATENTS-USA–					
4,784,037	15:7869	Patent and Trademark Office, Box 9, Washington, DC 20232			
PCCIM–					
CE-02786-2.vols	15:6829	Petroleum Society of the CIM, c/o AMOCO Canada, Box 200, Calgary, AB, CAN T2P 0H8. Prices: $80.00 CAN			
PNL–					
6696-HEDR-Rev.1	15:8579	NTIS, PC A06/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004036	MF-707
6976	15:7039	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004347	MF-511
7131	15:6985	NTIS, PC A08/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004982	MF-510
7143	15:6986	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004456	MF-812
PNL-SA–					
16980	15:8941	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004113	MF-423
16991	15:8801	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004115	MF-423
17021	15:8942	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004112	MF-423
17057	15:7510	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003636	MF-523
17227	15:8062	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004111	MF-404
17248	15:7574	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003639	MF-520
17293	15:7040	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004117	MF-602
17297	15:8943	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004116	MF-423
17455	15:7041	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003635	MF-630
17480	15:8944	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004114	MF-423
PPPL–					
2663	15:8850	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004372	PC-427
PTB-SE–					
24	15:6987	NTIS (US Sales Only), PC A04/MF A01		DE90732496	
PWR-RDMC-MWG-P–					
(88)199M	15:7888	*See* CEGB-RD-B–6092/R89			
QCTF–					
87-P16	15:8090	*See* AERE-R–13137			
RAL–					
89-060	15:8341	NTIS (US Sales Only), PC A04/MF A01 - OSTI; INIS		DE90612635	
89-063	15:8342	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90612646	
89-065	15:8663	NTIS (US Sales Only), PC A06/MF A01 - OSTI; INIS		DE90611041	
89-067	15:8791	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611498	
89-068	15:8792	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611499	
89-069	15:8628	NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS		DE90611415	
89-072	15:8704	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611470	
89-075	15:8343	NTIS (US Sales Only), PC A02/MF A01 - OSTI; INIS		DE90612647	
RFP–					
4384	15:7042	NTIS, PC A04/MF A01 - OSTI		DE90003811	MF-707

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RFW–					
87-03724	15:7681	PC Ontario. Ministry of Consumer and Commercial Relations, Communications Branch, 555 Yonge St., 9th Floor, Toronto, ON, CAN M7A 2H6; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN			
RHO-BWI–					
723TP01	15:6988	OSTI; INIS		TI90004685	MF-813
810DD01	15:6989	OSTI; INIS		TI90004684	MF-813
RHO-BWI-AP–					
006	15:6990	OSTI; INIS		TI90004576	MF-813
RHO-BWI-ATP–					
002	15:6991	OSTI; INIS		TI90004575	MF-813
RHO-BWI-CDR–					
002	15:6992	OSTI; INIS		TI90004577	MF-813
RHO-BWI-CR–					
005	15:6993	OSTI; INIS		TI90004558	MF-813
015	15:6994	OSTI; INIS		TI90004220	MF-813
018	15:6995	OSTI; INIS		TI90004590	MF-813
022-Rev.4	15:6996	OSTI; INIS		TI90004592	MF-813
RHO-BWI-DCR–					
001	15:6997	OSTI; INIS		TI90004599	MF-813
005	15:6998	OSTI; INIS		TI90004597	MF-813
009	15:6999	OSTI; INIS		TI90004600	MF-813
010	15:7000	OSTI; INIS		TI90004593	MF-813
RHO-BWI-DP–					
001	15:7001	OSTI; INIS		TI90004586	MF-813
008	15:7002	OSTI; INIS		TI90004584	MF-813
011-Rev.2	15:7003	OSTI; INIS		TI90004583	MF-813
012	15:7004	OSTI; INIS		TI90004582	MF-813
035-Rev.3	15:7005	OSTI; INIS		TI90003865	MF-813
041-Rev.1	15:7006	OSTI; INIS		TI90003867	MF-813
051-Rev.2	15:7007	OSTI; INIS		TI90003874	MF-813
053	15:7008	OSTI; INIS		TI90003877	MF-813
054	15:7009	OSTI; INIS		TI90003878	MF-813
056	15:7010	OSTI; INIS		TI90003880	MF-813
058	15:7011	OSTI; INIS		TI90003881	MF-813
RHO-BWI-DR–					
001-Vols.1-2-Rev.2	15:7012	OSTI; INIS		TI90004206	MF-813
RHO-BWI-ER–					
011	15:7013	OSTI; INIS		TI90004627	MF-813
011-Rev.1	15:7014	OSTI; INIS		TI90003862	MF-813
012-Rev.1	15:7015	OSTI; INIS		TI90004628	MF-813
013	15:7016	OSTI; INIS		TI90003863	MF-813
RHO-BWI-ES–					
020	15:7017	OSTI; INIS		TI90004200	MF-813
023	15:7018	OSTI; INIS		TI90004204	MF-813
RHO-BWI-TC–					
026-Rev.2	15:7019	OSTI; INIS		TI90004563	MF-813
RHO-BWI-TD–					
001	15:7020	OSTI; INIS		TI90004549	MF-813
009	15:7021	OSTI; INIS		TI90004554	MF-813
017	15:7022	OSTI; INIS		TI90004324	MF-813
019	15:7023	OSTI; INIS		TI90004325	MF-813
RHO-BWI-TI–					
059	15:7024	OSTI; INIS		TI90004345	MF-813
167	15:7025	OSTI; INIS		TI90004201	MF-813
RHO-BWI-TP–					
002	15:7026	OSTI; INIS		TI90004503	MF-813
005	15:7027	OSTI; INIS		TI90004505	MF-813
007	15:7028	OSTI; INIS		TI90004216	MF-813
RISO-M–					
2597	15:8851	NTIS (US Sales Only), PC A03/MF A01		DE90729636	
2608	15:7629	NTIS (US Sales Only), PC A06/MF A01		DE90728133	
2608(app.1)	15:7049	NTIS (US Sales Only), PC A05/MF A01		DE90728134	
2608(app.2)	15:7050	NTIS (US Sales Only), PC A06/MF A01		DE90728164	
2608(app.3)	15:7630	NTIS (US Sales Only), PC A03/MF A01		DE90728165	
2608(app.4)	15:7631	NTIS (US Sales Only), PC A04/MF A01		DE90728166	
2608(app.5)	15:7632	NTIS (US Sales Only), PC A08/MF A01		DE90728167	

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
2767	15:9000	NTIS (US Sales Only), PC A05/MF A01 - OSTI; INIS		DE90610990	
2768	15:7453	NTIS (US Sales Only), PC A05/MF A01		DE90728136	
2775	15:8852	NTIS (US Sales Only), PC A03/MF A01		DE90729637	
2783	15:9003	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90610992	
2808	15:7682	NTIS (US Sales Only), PC A06/MF A01		DE90728132	
2810	15:6856	NTIS (US Sales Only), PC A07/MF A01		DE90728135	
RPC–					
MDP/88/17	15:8186	PC Canada Centre for Mineral and Energy Technology, Technical Information Division, 562 Booth St., Room 20C, Ottawa, ON, CAN K1A 0G1; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN			
RRK–					
89-17	15:8737	NTIS (US Sales Only), PC A03/MF A01		DE90733095	
89-18	15:8738	NTIS (US Sales Only), PC A02/MF A01		DE90733097	
89-19	15:8629	NTIS (US Sales Only), PC A03/MF A01		DE90733096	
89-20	15:8705	NTIS (US Sales Only), PC A03/MF A01		DE90733101	
S–					
89-04277	15:7205	PC Canada Mortgage and Housing Corporation, Annex Bldg., 628 Montreal Rd., Ottawa, ON, CAN K1A 0P7; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN			
SAND–					
88-7058	15:7592	NTIS, PC A04/MF A01; OSTI; INIS		DE90004425	PC-523
89-0507C	15:8174	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004087	MF-704
89-0590C	15:7029	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003923	MF-721
89-0591C	15:7030	NTIS, PC A02/MF A01 - OSTI		DE90003921	MF-721
89-0734C	15:7031	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003922	MF-721
89-0782	15:8203	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002626	MF-706
89-1338C	15:8403	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003936	MF-702
89-1534C	15:8063	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003980	MF-704
89-1536C	15:7454	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002835	MF-261
89-1608C	15:9015	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003935	MF-706; MF-705
89-1619	15:8161	NTIS, PC A06/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004983	MF-705
89-1631C	15:7593	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003950	
89-1635C	15:7554	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89014967	MF-743
89-1729C	15:8162	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003057	MF-706
89-1791C	15:8017	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003574	MF-704
89-1795C	15:7455	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002834	MF-261
89-1822C	15:8064	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004198	MF-704
89-1860	15:7732	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004358	MF-900
89-1916C	15:9016	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89015845	MF-705
89-1955	15:8226	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004986	MF-411
89-2090	15:8065	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90005003	MF-404
89-2134C	15:7192	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002990	MF-700
89-2214C	15:7636	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90001537	MF-212
89-2277C	15:8349	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90000841	MF-706
89-2312C	15:7637	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002582	MF-212
89-2374C	15:8204	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90001178	MF-706
89-2476C	15:7456	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002575	MF-261
89-2531	15:9017	NTIS, PC A06/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004989	MF-705
89-2581C	15:9018	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003161	MF-705
89-2592C	15:9019	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002106	MF-705
89-2597C	15:7457	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002574	MF-261
89-2703C	15:7920	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003948	MF-741
89-2712	15:9020	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002902	MF-705
89-2733C	15:7625	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003486	
89-7037	15:7458	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002628	MF-261
89-7146C	15:6678	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003920	MF-700
89-8224	15:8066	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004348	MF-704

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
SCBC–					
89-03687	15:8205	PC British Columbia Legislative Library, Government Documents Division, Parliament Buildings, Victoria, BC, CAN V8V 1X4; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN			
SERI/TP–					
211-3604	15:7151	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89009513	MF-270
257-3558	15:7459	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89009507	MF-261
257-3589	15:7460	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89009508	MF-261
SI-R–					
860612-2	15:6895	NTIS (US Sales Only), PC A07/MF A01		DE90728247	
SI/R–					
881003	15:8468	NTIS (US Sales Only), PC A04/MF A01		DE90728225	
89243-1	15:8467	NTIS (US Sales Only), PC A03/MF A01		DE90728216	
SIWG-LASG-P–					
(89)382	15:7889	*See* CEGB-RD-B–6107/R89			
(89)383	15:7890	*See* CEGB-RD-B–6108/R89			
SJF-Beretning–					
43	15:7839	NTIS (US Sales Only), PC A04/MF A01		DE90728155	
SKB-TR–					
89-03	15:8611	NTIS (US Sales Only), PC A04/MF A01		DE90728327	
SLAC–					
353	15:8691	NTIS, PC A12/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004450	PC-414
354	15:8344	NTIS, PC A99/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004368	PC-414
SLAC-PUB–					
5055	15:8706	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004612	PC-414
5127	15:8255	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004432	PC-414
SNV–					
3577	15:7874	NTIS (US Sales Only), PC A06/MF A01		DE90728325	
3578	15:8404	NTIS (US Sales Only), PC A03/MF A01		DE90728300	
3582	15:8405	NTIS (US Sales Only), PC A04/MF A01		DE90728301	
3584	15:8469	NTIS (US Sales Only), PC A06/MF A01		DE90728302	
3585	15:8470	NTIS (US Sales Only), PC A03/MF A01		DE90728303	
3600	15:8471	NTIS (US Sales Only), PC A04/MF A01		DE90728304	
3606	15:8472	NTIS (US Sales Only), PC A03/MF A01		DE90728333	
3608	15:8473	NTIS (US Sales Only), PC A04/MF A01		DE90728305	
3610	15:8474	NTIS (US Sales Only), PC A03/MF A01		DE90728306	
3617	15:8475	NTIS (US Sales Only), PC A04/MF A01		DE90728307	
SRC–					
E-906-14-D-86	15:7509	PC Information Centre Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, SK, CAN S7N 2X8; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN			
SSS-R–					
82-5410	15:8366	NTIS, PC A06/MF A01 - OSTI		DE90003445	
STEV-FBT–					
89-29	15:6760	NTIS (US Sales Only), PC A02/MF A01		DE90728282	
89-32	15:8406	NTIS (US Sales Only), PC A03/MF A01		DE90728283	
89-33	15:8407	NTIS (US Sales Only), PC A03/MF A01		DE90728290	
89-34	15:8408	NTIS (US Sales Only), PC A03/MF A01		DE90728284	
89-35	15:8409	NTIS (US Sales Only), PC A03/MF A01		DE90728285	
89-36	15:8410	NTIS (US Sales Only), PC A03/MF A01		DE90728286	
89-38	15:8411	NTIS (US Sales Only), PC A02/MF A01		DE90728291	
89-40	15:8149	NTIS (US Sales Only), PC A04/MF A01		DE90728287	
89-44	15:8100	NTIS (US Sales Only), PC A03/MF A01		DE90728288	
89-46	15:6813	NTIS (US Sales Only), PC A03/MF A01		DE90728289	
STEV-TORV–					
89-7	15:6776	NTIS (US Sales Only), PC A03/MF A01		DE90728292	
89-8	15:8412	NTIS (US Sales Only), PC A03/MF A01		DE90728293	
STEV-VIND–					
89-15	15:7430	NTIS (US Sales Only), PC A03/MF A01		DE90728281	
89-16	15:7461	NTIS (US Sales Only), PC A03/MF A01		DE90728335	
89-19	15:7462	NTIS (US Sales Only), PC A03/MF A01		DE90728294	
STF–					
11A89036	15:7647	NTIS (US Sales Only), PC A03/MF A01		DE90728264	
60A84053	15:8463	*See* NHL–284053			

Report Number	Abstract Number	Source of Availability	GPO Dep.	Order Number	Distribution Category
60A89052	15:8612	NTIS (US Sales Only), PC A13/MF A01		DE90728265	
60A89077	15:8613	NTIS (US Sales Only), PC A03/MF A01		DE90728266	
71A89010	15:8200	NTIS (US Sales Only), PC A04/MF A01		DE90728267	
71A89034	15:8201	NTIS (US Sales Only), PC A06/MF A01		DE90728268	
STU–					
81-4243	15:7626	NTIS (US Sales Only), PC A03/MF A01		DE90728274	
85-3614	15:7875	NTIS (US Sales Only), PC A04/MF A01		DE90728331	
87-1790	15:7840	NTIS (US Sales Only), PC A07/MF A01		DE90728277	
87-3352	15:7841	NTIS (US Sales Only), PC A03/MF A01		DE90728278	
87-3794	15:7876	NTIS (US Sales Only), PC A03/MF A01		DE90728280	
87-530	15:7096	NTIS (US Sales Only), PC A03/MF A01		DE90728275	
87-616	15:7772	NTIS (US Sales Only), PC A02/MF A01		DE90728276	
88-2837	15:7842	NTIS (US Sales Only), PC A05/MF A01		DE90728332	
88-3749	15:7627	NTIS (US Sales Only), PC A03/MF A01		DE90728279	
SU–					
CE-02826	15:7206	Energy, Mines and Resources Canada, Communications Branch, 580 Booth St., Ottawa, ON, CAN K1A 0E4. Prices: PRICES UPON REQUEST			
SV-UB–					
1987-29	15:7757	NTIS (US Sales Only), PC A06/MF A01		DE90728297	
SV-UL–					
89-14	15:7808	NTIS (US Sales Only), PC A02/MF A01		DE90728298	
89-21	15:7864	NTIS (US Sales Only), PC A03/MF A01		DE90728299	
Stralenbescherming–					
40	15:8413	NTIS (US Sales Only), PC A08/MF A01 - OSTI		DE90705965	
TAU–					
CE-01344	15:7417	PC TransAlta Utilities Corporation, 110-12th Ave. SW, PO Box 1900, Calgary, AB, CAN T2P 2M1; MF CANMET/TID, Energy, Mines and Resources Canada, 555 Booth St., Ottawa, Ont., Canada K1A 0G1. Prices: PC PRICES UPON REQUEST; MF $10 CAN			
TK–					
21015-3	15:7594	*See* VROM–90044/2-89			
21015-1/2	15:7595	*See* VROM–90045/2-89			
TRI-PP–					
89-35	15:8256	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004271	
89-36	15:8257	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004272	
89-37	15:8258	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004273	
89-38	15:8259	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004274	
89-39	15:8227	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004275	
89-40	15:8260	NTIS (US Sales Only), PC A02/MF A01 - OSTI	E 1.99:	DE90004276	
89-41	15:7045	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004277	
89-42	15:8228	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004286	
89-44	15:8261	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004287	
89-47	15:8271	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004288	
89-71	15:8229	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004278	
89-72	15:8234	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004279	
89-73	15:8235	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004280	
89-75	15:8236	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004281	
89-76	15:8237	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004282	
89-77	15:8238	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004283	
89-78	15:8239	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004284	
89-96	15:8230	NTIS (US Sales Only), PC A02/MF A01 - OSTI		DE90004285	
UBA-FB–					
87-038	15:6897	Copy held by UB/TIB Hannover			
UCB-PTH–					
89/16	15:8735	*See* LBL–27475			
UCID–					
21821	15:8945	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004444	MF-420
UCRL–					
100043	15:7922	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002992	MF-706; MF-704
100614	15:8802	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003620	MF-705
100615	15:8803	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003618	MF-705
100960	15:8367	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003619	
101156	15:8368	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89014041	MF-702
101246	15:8345	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003837	MF-706
101851	15:8630	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003622	MF-700
101948	15:8631	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90001169	MF-744

UCRL–

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102003	15:8632	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003617	MF-700
102181	15:8633	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003594	MF-700
102238	15:8634	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003597	MF-700
102240	15:8635	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003602	MF-700
102243	15:8636	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003595	MF-700
21193	15:8067	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003022	MF-706
21216	15:6889	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003918	MF-702
21234	15:8068	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003990	
21243	15:8175	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002977	MF-706
21245	15:8163	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003471	
21251	15:8206	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003929	MF-706
21252	15:7921	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003930	
21253	15:8176	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003928	MF-706
95581	15:8853	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90002885	MF-700
UNC/GJ–					
103	15:6961	*See* DOE/ID/12584–49			
UzlYaF-R–					
10-344	15:8111	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611719	
10-395	15:8112	NTIS (US Sales Only), PC A03/MF A01 - OSTI; INIS		DE90611720	
VROM–					
90044/2-89	15:7594	NTIS (US Sales Only), PC A11/MF A01 - OSTI		DE90705964	
90045/2-89	15:7595	NTIS (US Sales Only), PC A04/MF A01 - OSTI		DE90705963	
VTT-SYMP–					
102	15:7843	NTIS (US Sales Only), PC A19/MF A01		DE90728202	
98	15:6498	NTIS (US Sales Only), PC A09/MF A01		DE90728211	
VTT-TIED–					
1013	15:6777	NTIS (US Sales Only), PC A04/MF A01		DE90728185	
1021	15:7865	NTIS (US Sales Only), PC A03/MF A01		DE90728186	
1050	15:7810	NTIS (US Sales Only), PC A04/MF A01		DE90728184	
991	15:7809	NTIS (US Sales Only), PC A05/MF A01		DE90728187	
999	15:8414	NTIS (US Sales Only), PC A07/MF A01		DE90728213	
VTT-TUTK–					
620	15:7811	NTIS (US Sales Only), PC A05/MF A01		DE90728179	
625	15:7812	NTIS (US Sales Only), PC A04/MF A01		DE90728212	
627	15:6761	NTIS (US Sales Only), PC A05/MF A01		DE90728183	
629	15:6762	NTIS (US Sales Only), PC A04/MF A01		DE90728182	
636	15:6814	NTIS (US Sales Only), PC A06/MF A01		DE90728180	
638	15:6898	NTIS (US Sales Only), PC A04/MF A01		DE90728181	
VW-FMT–					
8902V/5	15:7877	NTIS (US Sales Only), PC A03/MF A01		DE90732334	
WHC-SP–					
0446	15:9004	NTIS, PC A04/MF A01 - OSTI		DE90003515	MF-600
WSRC-RP–					
1062	15:8482	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003891	MF-702
89-1015	15:7032	NTIS, PC A08/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003905	MF-702
89-1039	15:8477	NTIS, PC A04/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003987	PC-702
89-1058	15:8478	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004269	MF-702
89-1059	15:7033	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90004268	MF-702
89-1060	15:8479	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003885	MF-702
89-1063	15:8480	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003890	MF-702
89-1064	15:8481	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90003894	MF-702
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(913) 864-4662

UNIV. OF KENTUCKY LIBRARIES
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(606) 257-3139

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Middleton Library
Govt. Docs. Dept.
Baton Rouge, LA 70803
(504) 388-2570

LOUISIANA TECHNICAL UNIV. LIBRARY
Documents Department
Ruston, LA 71272
(318) 257-4962

UNIVERSITY OF MAINE
Raymond H. Fogler Library
Tri-State Regional Documents Depository
Orono, ME 04469
(207) 581-1680

UNIVERSITY OF MARYLAND
McKeldin Lib.-Doc. Div.
College Park, MD 20742
(301) 454-3034

BOSTON PUBLIC LIBRARY
Government Docs. Dept.
Boston, MA 02117
(617) 536-5400 ext. 226

DETROIT PUBLIC LIBRARY
Sociology Department
5201 Woodward Avenue
Detroit, MI 48202
(313) 833-1409

MICHIGAN STATE LIBRARY
P.O. Box 30007
Lansing, MI 48909
(517) 373-0640

UNIVERSITY OF MINNESOTA
Government Pub. Division
409 Wilson Libra.;
309 19th Avenue So. h
Minneapolis, MN 554)5
(612) 373-7813

UNIV. OF MISSISSIPPI LIB.
Documents Department
University, MS 38677
(601) 232-5857

UNIV. OF MONTANA
Mansfield Library
Documents Division
Missoula, MT 59812
(406) 243-6700

NEBRASKA LIBRARY COMM.
Federal Documents
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Lincoln, NE 68508
(402) 471-2045
(in cooperation with University of Nebraska-Lincoln)

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Govt. Pub. Department
Reno, NV 89557
(702) 784-6579

NEWARK PUBLIC LIBRARY
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Newark, NJ 07101
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UNIVERSITY OF NEW MEXICO
Zimmerman Library
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Albuquerque, NM 87131
(505) 277-5441

NEW MEXICO STATE LIBRARY
Reference Department
325 Don Gaspar Avenue
Santa Fe, NM 87501
(505) 827-2033, ext. 22

NEW YORK STATE LIBRARY
Empire State Plaza
Albany, NY 12230
(518) 474-5563

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL
Wilson Library
BA/SS Documents Division
Chapel Hill, NC 27515
(919) 962-1321

UNIVERSITY OF NORTH DAKOTA
Chester Fritz Library
Documents Department
Grand Forks, ND 58202
(701) 777-2617, ext. 27
(in cooperation with North Dakota State Univ. Library)

STATE LIBRARY OF OHIO
Documents Department
65 South Front Street
Columbus, OH 43215
(614) 462-7051

OKLAHOMA DEPT. OF LIBRARIES
Government Documents
200 NE 18th Street
Oklahoma City, OK 73105
(405) 521-2502

OKLAHOMA STATE UNIV. LIB.
Documents Department
Stillwater, OK 74078
(405) 624-6546

PORTLAND STATE UNIV. LIB.
Documents Department
P.O. Box 1151
Portland, OR 97207
(503) 229-3673

STATE LIBRARY OF PENN.
Government Pub. Section
P.O. Box 1601
Harrisburg, PA 17105
(717) 787-3752

TEXAS STATE LIBRARY
Public Services Department
P.O. Box 12927-Cap. Sta.
Austin, TX 78753
(512) 471-2996

TEXAS TECH. UNIV. LIBRARY
Govt. Documents Department
Lubbock, TX 79409
(806) 742-2268

UTAH STATE UNIVERSITY
Merrill Library, U.M.C. 30
Logan, UT 84322
(801) 750-2682

UNIVERSITY OF VIRGINIA
Alderman Lib.-Public Doc.
Charlottesville, VA 22901
(804) 924-3133

WASHINGTON STATE LIBRARY
Documents Section
Olympia, WA 98504
(206) 753-4027

WEST VIRGINIA UNIV. LIB.
Documents Department
Morgantown, WV 26506
(304) 293-3640

MILWAUKEE PUBLIC LIBRARY
814 West Wisconsin Avenue
Milwaukee, WI 53233
(414) 278-3000

ST. HIST. LIB. OF WISCONSIN
Government Pub. Section
816 State Street
Madison, WI 53706
(608) 262-4347

WYOMING STATE LIBRARY
Supreme Ct. & Library Bld.
Cheyenne, WY 82002
(307) 777-6344

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